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Volume V: Water

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CENTRAL FLORIDA PHOSPHATE INDUSTRY AREAWIDE IMPACT ASSESSMENT PROGRAM

Volume V: Water

TEXAS INSTRUMENTS INCORPORATED
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This volume of a 7-volume environmental impact assessment of the phosphate industry in seven counties of central Florida documents information on the surface and subsurface water systems. One chapter addresses water quantity and quality, while a second chapter presents a baseline ecological characterization of the various aquatic communities in the counties studied (Hillsborough, Charlotte, Manatee, Hardee, Polk, Sarasota, and DeSoto).

Water quantity is described through such information as location of sources and watershed boundaries; water rights; existing potable systems and administrative procedures for regulating consumption; points and rates of surface-water withdrawal; the water table's relationship with other subsurface aquifers; and the relationship between existing and future water usage and existing and future resources. Water quality of appropriate stream segments is characterized, violations of standards indicated, major point and nonpoint sources of pollution identified, future phosphate industry loadings projected, and historical problems discussed.

The ecological characterization deals specifically with threatened and endangered species, species of commercial and recreational importance, nuisance and pest species, and resource management in the standing and running freshwater communities and estuarine and bay communities.

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Freshwater fishes
Industrial water
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Runoff
Stream flow
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FOREWORD

This is one in a series of reports presenting information developed by, or supplied to, Texas Instruments Incorporated (TI) while conducting an areawide environmental impact assessment of the central Florida phosphate industry for the Environmental Protection Agency (EPA). Because of the diversity and number of groups and individuals interested in this program, the EPA and TI encouraged active public involvement by making working papers available for review and comment as they were developed through environmental analysis, impact assessment, and alternative selection. These working papers then were prepared as a series of reports incorporating the original material modified through the incorporation of comments and additional information developed by TI. Other reports in the series include:

Volume	Title
I	Program and Industry Description
II	Environmental Permits and Approvals Relating to Phosphate Mining and Fertilizer Manufacturing in Florida
III	Socioeconomics
IV	Atmosphere
VI	Land
VII	Impacts of Alternative Public Policies on Social, Economic, and Natural Environmental Systems

These reports are made available through the National Technical Information Service to serve as background information to the environmental statements (draft and final) and environmental planning needs of federal, state and local agencies as well as other interested parties. The information will be of value to those involved with development and regulation of the phosphate industries, others who plan developments in central Florida, and environmental planners in general who must deal with environmental issues on a regional basis. It is hoped their use will lead to good decisions. It has often been said that decisions are only as good as the information on which they are based. Extending that philosophy, decisions are only as good as the decision makers' understanding of the adequacy of the information in resolving the issues being examined.

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3 Existing and Proposed Surface-Water Systems

4 Characteristic Water Quality for Study Area, January 1970 - December 1976

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CHAPTER 1

WATER QUANTITY AND QUALITY

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SECTION 1

WATER QUANTITY

A. INTRODUCTION

1. Purpose

The central Florida phosphate industry is a major user of the water resources in the seven counties being studied for this areawide impact assessment program; thus, the industry's impact on these water resources had to be judged in the same manner used for the other natural resources. First, the hydrologic regimes and dynamics of the hydrologic cycle operational in central Florida had to be understood, then the present as well as projected conditions examined in relation to hydrological conditions. Such an assessment required that Texas Instruments examine existing documents and data, with the assistance of consultants and staff members of federal and state agencies, and document in this report the information regarding surface and subsurface water systems necessary to assess the effects of water demands in the area.

Specific information presented in this report includes:

- General
  - Location of surface-water bodies and groundwater resources
  - Watershed boundaries
  - 100-year flood-prone areas
  - Expected 1-in-10-year 24-hour and 1-in-25-year 24-hour rainfall events
- Water Rights
- Water Supply
  - Existing potable water-supply systems (including those under construction)
  - Administrative procedures for regulating consumption

- Surface Water
  - Storage volumes
  - Average runoff in the area
  - Flow rates (including frequency and duration of seasonal variations and recorded maximums)
  - Major regulation structures and diversions (existing or proposed)
  - Points and rates of withdrawal
- Subsurface Water
  - Water budget (including recharge, inflow, outflow, and withdrawal)
  - Transmissivity
  - Storage volume
  - Confining-bed characteristics
  - Definition and seasonal changes in potentiometric surface
  - Definition of the water table and its relationships with other subsurface aquifers
  - Mineralized-water locations and relationships with potable water
  - Water-use locations and rates (present and projected)
  - Existing and future water-usage relationship with existing and future water resources (surface as well as subsurface)

2. Sources of Data

The results of the study were based entirely on analyses of existing data (reports, bulletins, maps, articles, and books prepared by many private and public organizations and agencies). The major data sources included the U.S. Army Corps of Engineers, Southwest Florida Water Management District (SWFWMD), U.S. Geological Survey (USGS), Florida Bureau of Geology, U.S. Department of Agriculture (USDA), Sarasota County Planning Department, Tampa Bay Regional Planning Council, Southwest Regional Planning Council, Florida Department of Environmental Regulation (DER), U.S. Environmental Protection Agency (USEPA), and the Florida Phosphate Council.

3. Acknowledgments

Assisting Texas Instruments in the investigation of water quantity were Tomasino & Associates, Inc., of Temple Terrace, Florida (surface water) and Geraghty & Miller, Inc., of Tampa, Florida (ground water and effects assessment and analysis). The staffs of SWFWMD at Brooksville, Florida, and the USGS subdistrict office at Tampa, Florida, were especially helpful in determining baseline and water-demand information. Utilizing a digital computer model of the Floridan aquifer, the USGS also analyzed and interpreted the effects of pumpage by the present and projected phosphate industry activities.

B. HYDROLOGIC REGIME

1. Physiographic Overview

The study area encompasses approximately 6,242 square miles in westcentral Florida and covers most of Polk and Charlotte counties and all of Hillsborough, Manatee, Hardee, DeSoto, and Sarasota counties. The area is bordered on the north by Lake, Pasco, and Sumter counties and on the west by the Gulf of Mexico; the boundary generally coincides with the boundaries of the Southwest Florida Water Management District (SWFWMD) on the east and south. The area's principal streams are the Hillsborough, Alafia, Little Manatee, Manatee, Myakka, and Peace rivers; Horse and Shell creeks; and Big Slough canal.

The area is contained within two natural topographic regions:

- The Coastal Lowlands comprises low, nearly level plains (commonly called flatwoods); gently undulating to rolling areas with numerous intermittent ponds, swamps, and marshes; and sinkholes with many lakes and perennial streams.
- The Central Highlands is a ridge and sinkhole region that divides Polk County nearly in half and cuts across the county in a northwest-to-southeast direction.

Elevations range from sea level along the coast to nearly 300 feet above mean sea level (msl) in the Central Highlands of Polk County.

2. Hydrologic System

a. Climate

The following paragraphs deal with those aspects of the study area's climate that influence the amount of available water resources. (A more general description of the climate of the study area appears in Section 1 of Volume IV.)

Climatic characteristics of greatest significance to water resources are temperature, precipitation, and evapotranspiration. Temperature affects water consumption both directly and indirectly: directly, the relatively tropical year-round temperatures (e.g., no monthly averages below 15.5°C [60°F]) contribute to high evaporation; indirectly, high year-round temperatures create favorable conditions for year-round growth of natural vegetation - which results in high evapotranspiration* - and a long growing season permits multiple cropping, increasing the amount of water used in irrigation agriculture.

The study area's average annual rainfall is approximately 50-55 inches per year. Although there is rainfall each month, there is a distinct rainy season (June-September) and dry season (October-May). The rainy season accounts for approximately 60-65 percent of the annual rainfall. Hurricanes may contribute to late summer rainfall, but they occur infrequently. The annual dependable rainfall is defined as the amount of rainfall equaled or exceeded 70 percent of the time (SWFWMD 1977); another rainfall index is the median annual rainfall, or that amount exceeded 50 percent of the time. Table 1.1 indicates these and other rainfall parameters for the river basins within the study area.

The average 10-year 24-hour rainfall is 7.75 inches, and the average 25-year 24-hour rainfall is 9.5 inches. (For additional details, refer to Volume VII, Scenario 2.13.)

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*Evapotranspiration is a combination of water returned to the atmosphere either through transpiration by plants or evaporation from the land surface.

Table 1.1. Annual Rainfall for Basins in Study Area*

Basin	Median Annual**	Dependable Annual***	Dry Threshold[†]	Wet Threshold[‡]	Rainy-Season Median**
	Centimeters (Inches)				
Northwest Hillsborough	125.2 (49.3)	111.0 (43.7)	93.5 (36.8)	152.4 (60.0)	75.2 (29.6)
Hillsborough	136.4 (53.7)	125.7 (49.5)	108.5 (42.7)	166.4 (65.5)	82.6 (32.5)
Alafia	136.4 (53.7)	126.5 (49.8)	106.7 (42.0)	169.2 (66.6)	87.9 (34.6)
Manasota[††]	136.4 (53.7)	125.2 (49.3)	106.2 (41.8)	164.6 (64.8)	88.6 (34.9)
Upper Peace	136.9 (53.9)	126.7 (49.9)	110.5 (43.5)	159.0 (62.6)	89.9 (35.4)
Lower Peace	133.1 (52.4)	120.7 (47.5)	103.9 (40.9	154.4 (60.8)	88.4 (34.8)

*SWFWMD (1977).

**Equaled or exceeded 50 percent of time.

***Equaled or exceeded 70 percent of time.

[†] A year with less rainfall than these values is classified as dry. Equaled or exceeded 90 percent of time.

[‡] A year with more rainfall than these values is classified as wet. Equaled or exceeded 10 percent of time.

[††] Includes Manatee River, Little Manatee, and Myakka River Basins.

Evapotranspiration in the study area is approximately 38 inches per year, and 60 percent of this occurs from May to October (SWFWMD 1977). The type of land-use/land-cover environment affects the rate of evapotranspiration; swamps and marshes typically have the greatest potential for high evapotranspiration rates because of the presence of free water surfaces and emergent vegetation. The rates in well-drained uplands vary greatly, depending on soil type, vegetation cover, and depth to the water table. Annual lake evaporation in the study area averages 49 inches (U.S. Army Corps of Engineers 1977). Although little information is available on evaporation in urban areas, it is known that runoff is relatively high because of the high percentage of impervious surfaces.

b. General Water Budget

To contribute to an understanding of the interrelationships of the various elements of the hydrologic system, a general water budget (Figure 1.1) was prepared using estimated, average, long-term values.

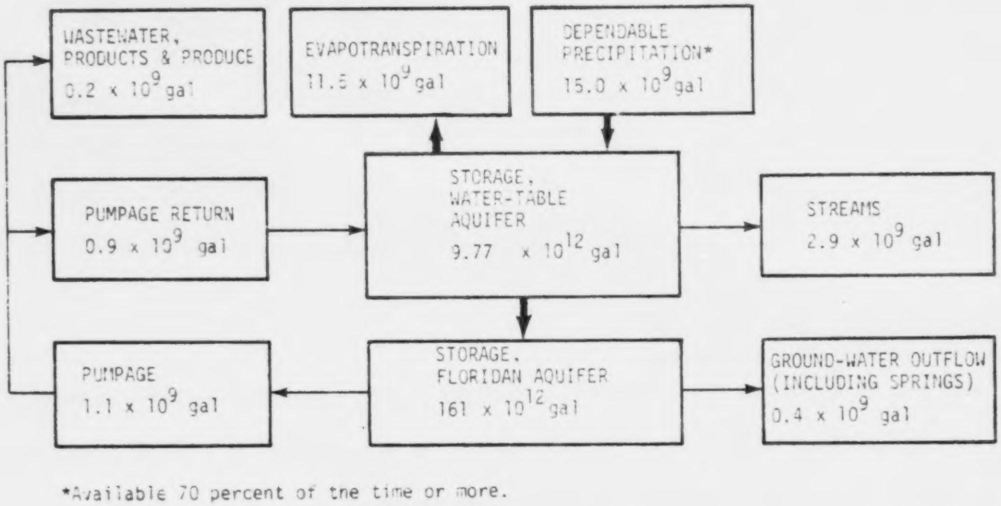

WASTEWATER, PRODUCTS & PRODUCE 0.2 x 10^9 gal
EVAPOTRANSPIRATION 11.5 x 10^9 gal
DEPENDABLE PRECIPITATION* 15.0 x 10^9 gal
PUMPAGE RETURN 0.9 x 10^9 gal
STORAGE, WATER-TABLE AQUIFER 9.77 x 10^12 gal
STREAMS 2.9 x 10^9 gal
PUMPAGE 1.1 x 10^9 gal
STORAGE, FLORIDAN AQUIFER 161 x 10^12 gal
GROUND-WATER OUTFLOW (INCLUDING SPRINGS) 0.4 x 10^9 gal
*Available 70 percent of the time or more.

Figure 1.1. Generalized Water Budget for Central Florida Phosphate District (prepared by Geraghty & Miller Inc.)

1) Precipitation

The average annual rainfall of approximately 16.3 billion gallons per day for the study area was derived by multiplying the mean annual rainfall by each basin area (SWFWMD 1977) in the district. The dependable annual rainfall (about 15.0 billion gallons per day) was computed for comparison.

2) Evaporation/Evapotranspiration

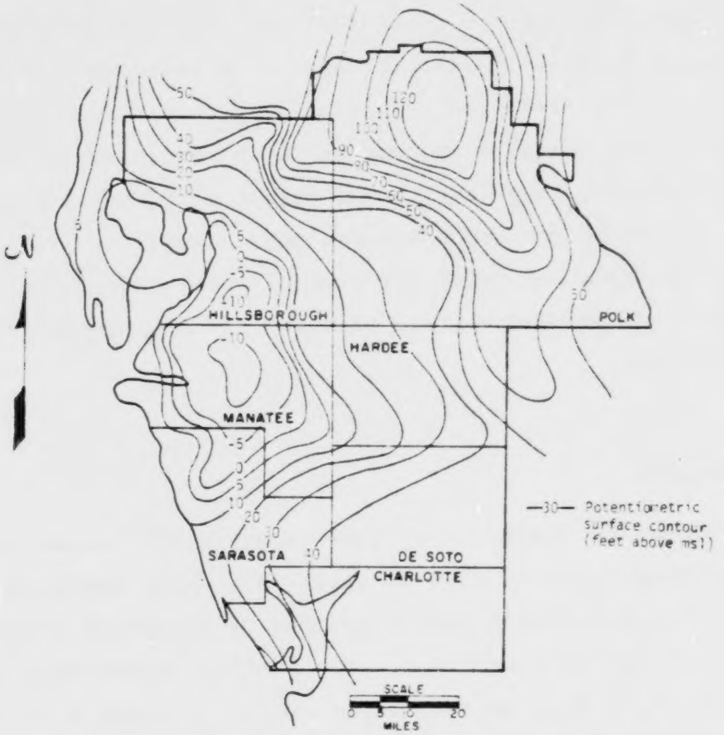
The evaporation and evapotranspiration losses throughout the district were computed based on various land-use classifications subdivided into four categories: urban, agricultural, range and forest, and water and wetlands. Using existing land-use acreages (detailed in Volume III of this series), urban areas (which include residential and commercial areas as well as transportation facilities, industrial complexes, and other built-up areas) represent approximately 9.0 percent of the total study area; agricultural land use accounts for 30.6 percent, and range and forest accounts for 36.6 percent of the total area; the remaining 23.8 percent is classified as water and wetlands. The annual evapotranspiration values are 25 inches for urban areas, 33 inches for range and forest areas, 39 inches for agricultural areas, and 48 inches for water and wetlands. Applying average evaporation and evapotranspiration rates for each of these categories to their acreages, the total average annual loss of water to the atmosphere is 11.5 billion gallons per day.

3) Runoff

To determine the amount of surface-water runoff in the study area, the discharge characteristics of each drainage basin were analyzed. An average discharge for the whole basin was determined by adjusting average historical runoff data provided by the USGS for the farthest downstream gaging station in each stream basin by a ratio between the total basin area and the drainage area covered by the gage. Whenever stream discharge data were not available for a basin, judgment was exercised in selecting an appropriate weighted discharge rate from a contiguous basin for which stream discharge data were available. Using this procedure, a discharge rate of 2.9 billion gallons per day was computed as the average surface-water runoff from the study area, based on a 20-year average (1955-74) flow.

4) Groundwater Inflows and Outflows

The amount of ground water leaving the study area was determined from a flow-net analysis of the potentiometric surfaces for September 1975 and May 1976 (Figures 1.2 and 1.3, respectively). The elevation of the potentiometric surface for these two time periods represents minimum (May) and maximum (September) groundwater outflows; thus, an average between the two most likely approximates an average for the study area. In determining the groundwater discharges, a transmissivity value representative of the total groundwater flow system was used. The flow-net analysis indicated that groundwater outflow in September 1975 was almost three times that of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—30— Potentiometric surface contour (feet above msl)
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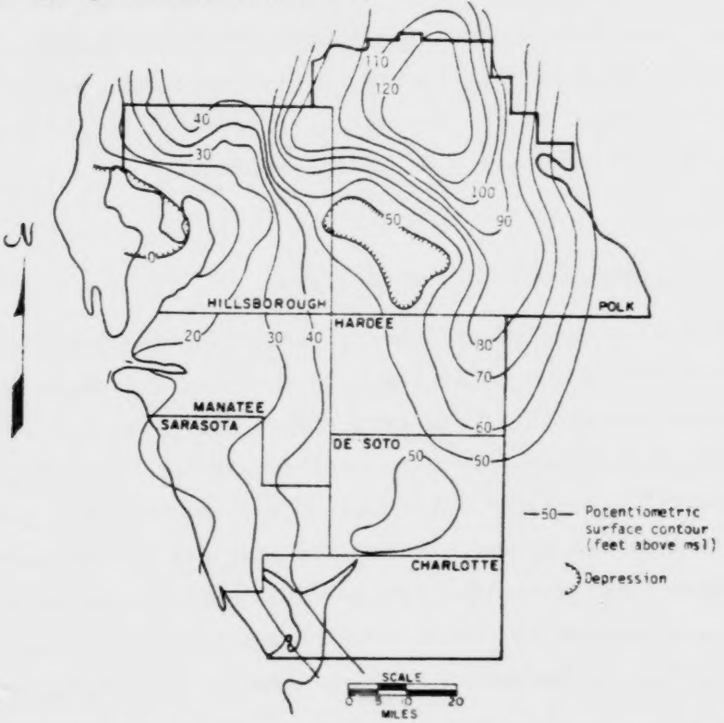
Figure 1.2. Potentiometric Surface of Floridan Aquifer for May 1976 (adapted from USGS data)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—50— Potentiometric surface contour (feet above msl)
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Figure 1.3. Potentiometric Surface of Floridan Aquifer for September 1975 (adapted from USGS data)

May 1976. The average value for the amount of ground water leaving the study area was approximately 0.4 billion gallons per day.

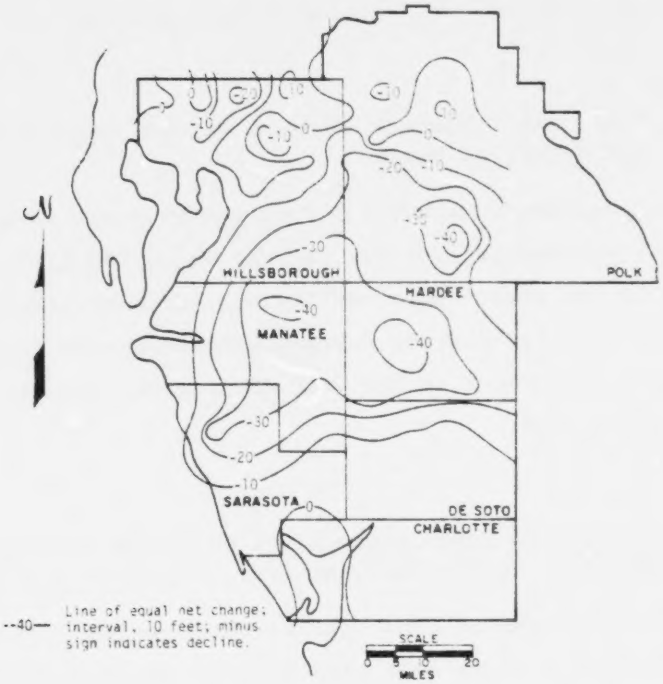
5) Groundwater Pumpage, Pumpage Return, Wastewater Discharge, and Export of Water

Total groundwater withdrawal from the Floridan aquifer is estimated to be 1,136 million gallons per day, of which 900 million gallons per day is returned to the water-table aquifer and surface-water systems. It is estimated that the Central Florida Phosphate District discharges 200 million gallons per day as wastewater to the Gulf or as water for use in agriculture and industrial production.

6) Changes in Water Storage and Estimated Average Annual Recharge to Floridan Aquifer

The total storage of fresh ground water in the Floridan aquifer underlying the Central Florida Phosphate District is estimated to be approximately 161 trillion gallons (Figure 1.1). However, the most important factor in the water budget is the extent or amount of change in storage in the past. The decline in the potentiometric surface between May 1969 and May 1975 (Figure 1.4) was the point of departure for the calculations. The area within a given drawdown contour was determined and was multiplied by the average drawdown and by the value of the storage coefficient of 1×10^{-4}. The volume of water calculated to have been taken out of storage between May 1969 and May 1975 was 1.69 billion gallons, which is the equivalent of a well pumping continuously for 6 years at a rate of 0.77 million gallons per day, or 535 gallons per minute. The total estimated groundwater withdrawal in this time interval was estimated to have been approximately 2.14 trillion gallons. Comparing the total pumpage to the change in storage, one can conclude that less than 0.08 percent of the total water pumped comes from storage depletion; i.e., nearly all of the pumpage (more than 99.92 percent) is being replaced by recharge.

The average 1975 recharge to the Floridan aquifer was calculated on the assumption that recharge essentially equals pumpage and groundwater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--40— Line of equal net change; interval, 10 feet; minus sign indicates decline.
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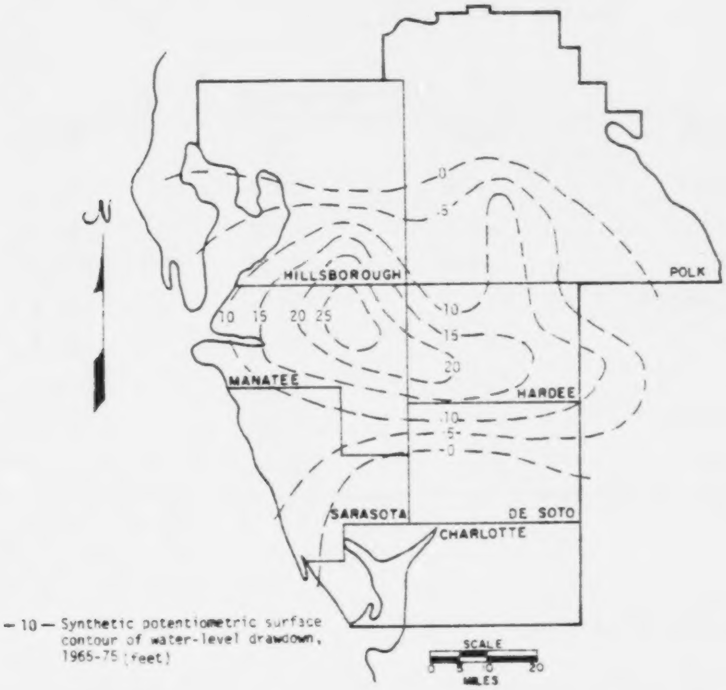
Figure 1.4. Change in Potentiometric Surface of Floridan Aquifer, May 1969 to May 1975 (adapted from USGS data)

outflow, which was 1,536 million gallons per day. The area of the recharge (i.e., where the altitude of the potentiometric surface was below that of the water table) was approximately 5,504 square miles. Dividing the groundwater outflow by the total area yielded an average recharge to the Floridan aquifer of 438 gallons per day per acre. Assuming a 10-foot head difference between the water table and the potentiometric surface, the leakance value would be 1.0×10^{-3} gallons per day per cubic foot. A head difference of 100 feet yields 1.0×10^{-4} gallons per day per cubic foot. These values of leakance are certainly within the range obtained by other analytical methods such as the evaluation of pumping tests, but their validity depends to a great extent on the validity of the numbers for the groundwater withdrawals and for the values of groundwater outflow. The number calculated for groundwater outflow was entered into the calculations of the value of leakance; had that not been done, leakance for a 10- and 100-foot head difference would have ranged between 7.4×10^{-4} and 7.4×10^{-5}.

The analysis of the change in storage seems to indicate that use of the groundwater system is causing the decline in the potentiometric surface (Figure 1.5); it does not indicate that the total storage is being depleted.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— 10 — Synthetic potentiometric surface contour of water-level drawdown, 1965-75 (feet)
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Figure 1.5. Decline of Synthetic Potentiometric Surface of Floridan Aquifer between May 1965 and May 1975 (adapted from USGS data)

7) Reliability of Available Data

There are inconsistencies in the data that can be explained only by questioning the reliability of the estimates for the groundwater withdrawals during 1965, 1970, and 1975.

The data in Table 1.2 show that groundwater withdrawals in 1970 were less than those in 1965. However, Figure 1.5 shows that the potentiometric surface of the Floridan aquifer from which most of the water is pumped declined in certain places by more than 25 feet. If withdrawals actually had been less, the potentiometric surface should not have shown this decline. It appears that, instead of a lessening of pumpage from

1965 to 1970, there was a large increase. A more careful analysis of the data by the USGS to obtain input data for its digital model simulation of the Floridan aquifer in the Central Florida Phosphate District is justified.

Table 1.2. Total Groundwater Withdrawals by Counties during 1965, 1970, 1975

	Million Gallons per Day		
County	1965	1970	1975
Charlotte	6.5	28.7	28.6
DeSoto	22.1	65.9	104.5
Hardee	39.8	63.3	188.3
Hillsborough	149.0	139.4	136.4
Manatee	87.3	52.8	68.7
Polk	562.0	419.8	563.3
Sarasota	41.2	45.9	46.7
Total	907.9	815.8	1,136.5

3. Surface-Water Resources

The surface-water resources of the study area encompass parts of all seven counties and include springs, wetlands, lakes, streams, and runoff within given watersheds (see Plate 1 in map pocket). The following subsections give an overview of the surface-water resources of the study area.

a. Watershed Characteristics

The major watersheds in the 7-county study area are the Hillsborough, Alafia, Little Manatee, Manatee, Myakka, and Peace rivers; the Tampa Bay area; the southern coastal area; and the Charlotte Harbor area.

1) Hillsborough River Basin

The Hillsborough River Basin includes portions of Hillsborough, Polk, and Pasco counties. The Hillsborough River is the principal drainage system, originating in the Green Swamp area and flowing into Hillsborough

Bay. The drainage area above the Tampa water-supply reservoir dam approximately 10 miles upstream from the mouth is 630 square miles. Crystal Springs, Sulphur Springs, and several smaller tributary springs feed the river. The second major stream of the area is Sixmile Creek (Palm River). Draining roughly 40 square miles, it discharges an estimated average 56 million gallons per day at its mouth into McKay Bay.

The upper reaches of the Hillsborough River show a relatively steep gradient; along a 6-mile stretch below the difference, the average fall is 1.3 feet per mile. Between Seaboard Coast Line Railroad and Atlantic Coast Line Railroad, there is a drop of 8.4 feet per mile. Despite the considerable gradient, floodplain vegetation over U.S. 98 is nearly 4,000 feet wide, while the 100-year flood-prone corridor is 3.5 miles wide on USGS maps. Immediately upstream of Blackwater Creek, the hardwood swamp forest vegetative association and the 100-year floodplain correspond and are reduced in width to approximately 3,000 feet. Downstream, Crystal Spring has a 0.5-mile run to the river near SR 39. The year-round spring flow assures a base flow downstream. USGS calculations show an average discharge of 60 cubic feet per second, with a range of 20-150 cubic feet per second over a 40-year period. A sizable canal system drains the area in and around the Zephyrhills Army Air Base and discharges into the Hillsborough River system via an unchannelized fringe of the hardwood swamp forest. A low-lying marshy strand within the Zephyrhills urban area, and including Lake Zephyr, undoubtedly receives storm runoff and perhaps domestic wastes as well. These waters are directed southward through a canal and discharge into the Hillsborough - but again through an unchannelized extension of the floodplain nearly 1 mile in length.

The lower Hillsborough River flows southwest from the diffluence point to Hillsborough Bay. Extensive floodplains and swamps up to 3 miles wide extend along the Hillsborough, New, and Blackwater rivers. Sulphur Springs is the only major tributary to the lower Hillsborough; the spring has a regulated outflow, and at times the Tampa Water Department pumps water directly from the spring pool into the Tampa reservoir. USGS records show an average discharge of 40 cubic feet per second and a range from more than 100 cubic feet per second to less than 5 over 16 years.

The lower Hillsborough River occupies a well-defined topographic channel. The area inundated by the flood of March 1960, as recorded on USGS maps, was restricted to this topographic channel and therefore was of limited extent. Since 1960, urban encroachment into this flood-prone area has been so extensive that similar floods would presently produce large economic losses. For this reason, the Corps of Engineers is proceeding with the construction of the Tampa bypass canal, which will divert high water in the area of Cow House Creek and Cypress Creek through the canal to be discharged to McKay Bay. The Corps estimates that flooding would affect 5,000 acres for a 2-year frequency, 11,000 acres for 10 years, and 18,000 acres for 100 years.

The Hillsborough River is currently channe[illegible]d along its first 1.5 miles. About 10 miles above the mouth is the Tampa water-works dam, which creates a reservoir used as a water-supply source for the city; the dam backs up water along the river to the Seaboard Coast Line Railroad tracks. The reservoir has considerable water-quality problems, as expressed by the abundance of aquatic weeds including water hyacinth, hydrilla, watermilfoil, and algae that reach nuisance proportions. Below the dam, the river is tidal. USGS gages the river at the dam and reports that discharge over 37 years has ranged from 15,000 cubic feet per second during the March 1960 flood to nearly zero flow when the control structure gates are closed much of the year, with the average being 600 cubic feet per second.

2) Alafia River Basin

This basin includes portions of Hillsborough and Polk counties as well as the Alafia River, which may be divided into three sections for the purpose of this study: the Alafia, the North Prong, and the South Prong. The confluence of the North and South prongs forms the Alafia in the Eastern section of Hillsborough County just north of Pinecrest. The Alafia River extends from the mouth at Hillsborough Bay eastward to the confluence of the

North and South prongs. Tributaries flowing into the Alfia include Rice, Bell, Fishhawk, Little Fishhawk, and Buckhorn creeks. Numerous hammocks flow into the tributaries south of the river. Major springs on the Alafia River and their discharges include the Buckhorn, 10.6 cubic feet per second (6/5/77); Messer, 1.1 cubic feet per second (estimated); and Lithia, 10.9 cubic feet per second (5/21/70).

The South Prong originates in Hooker's Prairie northeast of Brewster and drains approximately 120 square miles, flowing west and then north to its confluence with the North Prong. Average discharge at a gaging station 7.6 miles upstream from the confluence with the North Prong is 134 cubic feet per second; estimated flow of the South Prong at its mouth is 150 cubic feet per second. The floodplain in this area can be very wide. Generally, major flood-prone areas are confined to lands immediately adjacent to stream channels. Stream gradients along the South Prong are moderate. Elevations in the southern section are approximately 140 feet, while 14 miles away at the confluence of the North and South prongs elevations are approximately 40 feet, equal to a decline of 7 feet per mile.

The North Prong drains about 75 square miles, and its headwaters are in Polk County. Of the several tributaries, the largest are English and Poley creeks. The stream flows north from its headwaters to the Mulberry area and then west where it joins the South Prong. Average discharge at Keysville is about 180 cubic feet per second. The North Prong and its tributaries flow through a wide marshy and swampy area in poorly defined channels; consequently, the floodplain is quite wide and covers a considerable area. Generally, flood-prone areas are confined to land immediately adjacent to the stream channels. Stream gradients in this area are moderate.

The only soil type in most of the marshy and swampy areas is the freshwater swamp association (poorly drained soil subject to prolonged flooding). The land type found in this area is an association termed "mine, pits, and dumps." Runoff potential is moderate because of (1) relatively steep stream gradient, (2) the abundance of moderately well-drained soils, and (3) large swampy areas that retain surface waters and reduce runoff potential to a moderate rating. There are no natural lakes in this region. Most of the 630 acres of lakes were created by mining activities. There are numerous natural ponds and marshes throughout the area. Wetlands development is extensive (2,430 acres); most is fresh forest land, and nearly all is located along stream channels.

3) Little Manatee River Basin

The Little Manatee River Basin includes the southern portion of Hillsborough County and the northern portion of Manatee County. The principal drainage system is Little Manatee River, which originates in a swampy section of southeastern Hillsborough County and flows westward for approximately 40 miles to Tampa Bay, emptying near the town of Ruskin. The stream drains about 150 square miles in southern Hillsborough County and 75 square miles in northern Manatee County.

The Little Manatee River watershed is primarily in an area of extensive, nearly level plains rising from the coast to elevations of more than 100 feet in the eastern portion of Hillsborough County. Numerous intermittent ponds, swamps, and marshes and a few permanent lakes occur in these plains, as do many depressions, some of which contain water that has seeped or drained from surrounding soils. Drainage, which is provided by the swamps, sloughs, and the few large streams that pass through the area, is slow in the plains.

The Little Manatee River is the primary aquatic system in southwestern Hillsborough County. Associated with the river are numerous tributary streams. Wetlands development is fairly extensive in the vicinity of the river. Flood-prone areas are primarily restricted to lands adjacent to the river and its tributaries. Low-lying coastal areas subject to flooding from a 100-year hurricane event extend inland to the Seaboard Coast Line Railroad bed. There are also several low marsh areas that act as surface-water retention sites and are subject to ponding following intense rains. The downstream reach of the Little Manatee River fluctuates with tidal action in Tampa Bay, which is at times discernible as far as 5 miles upstream.

The middle reaches of the Little Manatee River and its headwaters and associated tributaries comprise the major aquatic system in southeastern Hillsborough County. Wetland developments in the area are abundant but not excessive. There are no salt wetlands in this subsegment because the coast is several miles west. Flood-prone areas are restricted to lands immediately adjacent to stream channels; several low-lying wetlands are subject to flooding following intense rains, but these sites are generally concentrated in the southeast corner of the county. Stream gradients in this section are quite low. Elevations near the Polk-Hillsborough-Manatee county lines are approximately 140 feet, while downstream at the Seaboard Coast Line Railroad bed elevations are about 20 feet. Between these points, there is a drop of 17 miles, which corresponds to slightly more than a drop in elevation of nearly 7 feet per mile. Stream gradients of the South Fork are quite steep. Elevations at the headwaters of some tributary creeks are 125 feet and have fallen to 45 feet 6 miles downstream, a drop of 13 feet per mile.

4) Manatee River Basin

The Manatee River basin lies primarily in a topographic area described as the Coastal Lowlands within the central portion of Manatee County.

The area comprises low, nearly-level plains and gently rolling hills; numerous ponds, swamps, and marshes; and intermittent tributary streams. Elevations range from sea level to approximately 100 feet above mean sea level in an area near the eastern edge of Manatee County. The rocks and sediments are of Miocene origin and include the Hawthorn and Bone Valley formations. The Hawthorn formation not only confines water but restricts recharge. Where its relatively impervious sediments lie at ground surface and cover the artesian aquifer, surface runoff can be expected to respond quickly to rainfall - but such runoff becomes increasingly intermittent at locations farther up the watershed.

The Manatee River drainage system originates in the eastern portion of Manatee County and flows west to the mouth of Tampa Bay; its drainage area is about 350 square miles. The discharge rate is variable and closely parallels rainfall patterns because there is no significant base flow from seeps or springs. Stream gradients are quite low. The outfall at Lake Manatee is approximately 35 feet in elevation, and the city of Palmetto at the mouth is nearly at sea level. This is a change of only 35 feet in approximately 13 miles. On the north fork near Duette, the elevation is approximately 120 feet; downstream, as the river enters the county impoundment, elevation drops to 40 feet.

Small ponds and marshes are abundant in undeveloped areas to the northeast of Palmetto and east of Bradenton. Outside urbanized sites, drainage ditches and canals are common features, especially in a section east of Palmetto and north of the Manatee River. Flood-prone areas are primarily confined to floodplains. Lake Manatee, which covers an area of 2,300 acres and has an estimated capacity of 10 to 13.5 billion gallons, is the primary source of water for the residents of Manatee County. Runoff potential in the area is moderate because of the moderately well-drained soils in two of the three major associations and the relatively steep stream gradient of the Manatee River. Agricultural development around the entire eastern end of Lake Manatee is extensive and may lead to future water-quality problems. Fertilizers, pesticides, and other agricultural chemicals washed into the lake can lead to rapid eutrophication and buildup of toxic materials in the sediments. There is already a considerable quantity of water hyacinths in the impoundment, and additional nutrient input will only serve to stimulate further growth.

5) Myakka River Basin

The Myakka River Basin includes approximately 191,600 acres, or 298.4 square miles. About 3,100 acres are in western Hardee County; 105,000 acres are in southeastern Manatee County; and 83,500 acres are in eastern Sarasota County. At the downstream end of the watershed is a portion of North Port Charlotte. A major subbasin is Big Slough canal, a tributary of the Myakka River. Joining the Myakka River at North Port, Big Slough has its headwaters in southern Manatee County and flows generally in a southwesterly direction across Sarasota County. It is significant in that the upper reaches drain an area in which phosphate mining will be developed in the future. Big Slough canal also provides a portion of the water supply of the city of North Port.

Swamps and marshes in western Manatee County form the Myakka River headwaters. Land surface altitudes range from sea level to about 115 feet above sea level at the headwaters of the Myakka River. The topography is generally flat at a distance from the streams, with a fairly sharp break from these flats into the stream channels. Except where deepened by man, the sloughs, which serve as tributaries to the larger streams, are seldom more than a few feet deep and range in width from several feet to more than a mile. Numerous wet-weather ponds dot the broad, flat landscape in the central part of the area where the water table is usually within a few feet of the ground surface. Marsh and swamps each occupy about 5 percent of the upland lying above 40 feet in elevation. Flood-prone areas are generally confined to those surrounding the Myakka River; they are less than 50 feet in elevation near Myakka City and less than 75 feet near Myakka Head. A flood-prone area approximately 3 miles north of Myakka City in a vast marsh-hardwood zone, where numerous small streams converge joining the Myakka River, covers approximately 3.5 square miles. Other flood-prone sites are low-lying wetlands (e.g., Coker Prairie) that act as surface-water storage areas. Wetlands development is fairly extensive, especially along the Myakka River and the tributary stream floodplains.

In a topographically low area near the center of its basin, the Myakka River flows through Upper and Lower Myakka lakes; both lakes are entirely within the Myakka River State Park. The combined lake area is about 1,388 acres, and depths over most of this area are usually between 5 and 6 feet; however, the levels of these lakes fluctuate widely with seasonal changes. Both lakes are considerably larger than any other perennial lakes in the area.

Surface waters derived from natural drainage are of good quality except for occasional high color and summer temperatures of about 32°C (90°F). Low flows in many channels in low-lying areas are often supplemented by waters of relatively high dissolved-solids content derived from irrigation wells and domestic waste. Streamflow data collected in the Myakka River Basin indicate that all nontidal reaches of streams in the area have ceased natural flows during at least five droughts since 1938. Many of these nontidal reaches go virtually dry during the late spring of most years. Effective utilization of streamflow is restricted by these frequent droughts as well as by a limited choice of practical storage sites. The Upper and Lower Myakka lakes through which the Myakka River flows occupy two of the largest natural depressions in the area and have a total storage capacity of approximately 8,100 acre-feet. Average discharge at a stream gaging station located between these lakes is 266 cubic feet per second, or about 192,000 acre-feet per year. Draft-storage studies indicate that these lakes will provide a continuous draft of at least 6.5 million gallons per day if their storage potential is adequately developed.

Streamflow and quality characteristics indicate negligible artesian groundwater contributions to the Myakka River in the reach between Myakka City and the outlet to Lower Myakka Lake. It is possible that the underlying connections with the stream channels are a small and relatively insignificant source of moderately mineralized ground water to the low flows of some streams (e.g., the Myakka River and Big Slough). The Upper and Lower Myakka lakes appear to be solution features and thereby offer the possibility that ground water from artesian zones may contribute to these lakes through debris-filled fractures or sinks; however, the lakes and the Myakka River channel are for the most part underlain by rather impermeable clays.

6) Peace River Basin

The Peace River Basin encompasses approximately 2,907 square miles of Polk, Hardee, DeSoto, and portions of Charlotte and Manatee counties. Generally, land and water elevations are high in the north and decrease southward toward Charlotte Harbor. The terrain of the northern section (approximately Limestone, Hardee County, and north) is a mixture of marshy flatlands and rolling hills at a high elevation; southward (south of Limestone, Hardee County), the terrain tends to flatten as the elevation decreases. There are many lakes and large areas of poorly drained swamplands; these areas of natural surface-water detention help to recharge shallow groundwater supplies and also make direct contributions to base or low flows. Natural lakes and swamplands tend to moderate the time distribution of surface runoff and therefore are very important to the natural hydrologic cycle; if the lake and swamps of the basin were drained, more severe floods and droughts would be expected. Included in the Peace River Basin are Horse, Shell, and Prairie creeks. Prairie Creek, a tributary of Shell Creek, has its headwaters in the proposed phosphate mining district of DeSoto County. Horse Creek is a major sub-basin of the Peace River Basin, joining the Peace River near Fort Ogden in DeSoto County and extending northerly through the westerly sections of Hardee and DeSoto counties.

The principal drainage system is the Peace River, which originates in an area known as the Green Swamp, an important recharge area for groundwater in central Florida. Originating on the southern boundary of Green Swamp are Saddle and Peace creeks, the two principal tributaries in central Polk County. The Peace Creek canal, which is 11.1 miles long and drains 160 square miles in the eastcentral sector of Polk County, is one of the collection points in the Green Swamp vicinity. Saddle Creek is only 2.8 miles long but drains 145 square miles. The Peace River itself begins at an elevation of 110 feet above msl and travels 105 miles, draining 2,300 square miles and flowing into Charlotte Harbor at sea level at Punta Gorda; Charlotte Harbor is a large bay having a surface area of 142 square miles and a mean depth of approximately 11 feet, which gives a volume of 43.5 billion cubic feet at mean low water.

The Peace River and its tributaries are the main topographic feature of DeSoto County. These streams and the Long Island marsh area in the southeast drain all of the county. There are no natural bodies of water large enough to be considered lakes, although the Fish and Game Commission does maintain a 40-acre pond in the southwest part of the county for conservation and recreational purposes. The Peace River floodplain is mostly narrow with a steep slope. The general land surface is composed of gently sloping terraces, while the areas between streams are mostly flat and poorly drained and subject to standing water during periods of prolonged or heavy rainfall.

The freshwater discharge of the Peace River is highly variable. Long-term discharge records are based on data from Arcadia since the tide will influence any gage heights below that point. A comparison of drainage areas indicates that these flows would have increased by about 30 percent between Arcadia and the SR 761 bridge near the river mouth. The maximum flow in 42 years of record from 1931 to 1973 at Arcadia was 36,200 cubic feet per second (23,395 million gallons per day) in 1933; the minimum was 37 cubic feet per second (24 million gallons per day) in 1949. The mean discharge for the period was 1,195 cubic feet per second (772 million gallons per day).

7) Tampa Bay Area

The Tampa Bay area includes the central and northwest portions of Hillsborough County, the eastern portion of Pinellas County, McKay Bay, the coastal area between the Alafia and the Little Manatee River basins and a small coastal area between the Little Manatee and the Manatee River basins. No permanent drainage systems have evolved in the small coastal areas. The principal streams that drain the northwest corner of Hillsborough County are Rocky and Sweetwater creeks; their average flows measured near upper Old Tampa Bay are 40 cubic feet per second (26 million gallons per day) and 25 cubic feet per second (16 million gallons per day) respectively. Several flood-relief channels are currently undergoing major improvements in order to reduce saltwater intrusion and improve water quality in the lower reaches of Rocky Creek.

8) Southern Coastal Area

The southern coastal area includes the western coastal area of Sarasota and Charlotte counties and the extreme southern coastal portion of Manatee County; it is part of the Coastal Lowlands and has relatively uniform land elevation and slope. The low land elevation, combined with the uniform local relief, creates a hazardous flood potential.

9) Charlotte Harbor Area

The Charlotte Harbor area includes Charlotte Harbor and adjacent areas with a northward extension into Sarasota County. The land west of Charlotte Harbor forms a low-lying plain peninsula, the altitude of which is generally less than 10 feet above sea level. The land east of the harbor forms a broad, gently sloping, sandy, low-level plain.

The coastal area of Charlotte County is undergoing rapid urbanization and is experiencing major problems in obtaining sufficient water of suitable quality to meet public requirements. This flatland county is drained by two major streams, the Myakka and Peace rivers, and many small streams and canals. Neither of the major streams is used currently as a drinking-water supply. Although the average rainfall is 54 inches per year, the low-flow characteristics are such that little or no flow will occur in most streams for as much as 30 consecutive days on the average once every 20 years. The chemical quality of water in most of the streams and canals is suitable for public water supplies; however, most of the favorable reservoir sites are already in use.

b. Springs

A spring represents natural overflow from an aquifer. The major springs within the study area generally discharge into surface-water bodies (the Hillsborough and Alafia rivers). Spring discharge varies naturally as a result of pumping and seasonal fluctuations of water levels (U.S. Army Corps of Engineers 1977). Table 1.3 indicates the magnitudes of the principal springs in the study area. They are primarily in Hillsborough and Sarasota counties (see Plate 1 in map pocket). Additional characteristics of each major spring are given in Table 1.4.

c. Wetlands

In its land-use/land-cover mapping programs, the USGS defines wetlands as areas in which the water table is at, near, or above the land surface for a significant part of most years. The hydrologic regime is such

Table 1.3. Magnitudes of Springs in Study Area*

County	Spring	Map Ref **	Magnitude of Avg Flow (cfs)
Hillsborough	Buckhorn	01	10-100
Hillsborough	Lithia	02	10-100
Hillsborough	Sulphur	03	10-100
Hillsborough	Eureka	04	10-100
Hillsborough	Lettuce Lake/ Six Mile Creek	05	<10
Hillsborough	Messer	06	<10
Hillsborough	Boiling	07	<10
Sarasota	Warm Salt	08	<10
Sarasota	Little Salt	09	<10

*U.S. Army Corps of Engineers (1977); SWFWMD (1975).

**See Plate 1.

Table 1.4. Characteristics of Major Springs in Study Area*

		Flow of Record					
		Mean		Max.		Min.	
Spring	Tributary To	(cfs)	(mgd)	(cfs)	(mgd)	(cfs)	(mgd)
Sulphur	Hillsborough River	40	25	160	100	4	2
Lithia	Alafia River	50	30	80	50	21	44
Total		2,250	1,455	6,620	4,265	745	481

*SWFWMD (1977)

that aquatic or hydrophytic vegetation is usually established (although alluvial and tidal flats may be nonvegetated). Wetlands frequently are associated with topographic lows and include marshes, mudflats, and swamps situated on the shallow margins of bays, lakes, ponds, streams, and man-made impoundments; wet meadows; and seasonally wet or flooded basins, playas, or potholes with no surface-water outflow. Wetlands comprise 12.34 percent of the land cover in the study area as interpreted from the map of existing land use found in Volume IV of this series of working papers. Table 1.5 is a list of those named wetlands. However, since there are many wetlands unnamed, some of which are larger than those listed, refer to maps in Volume III for a complete delineation of wetlands comprising the 12.34 percent area coverage.

Table 1.5. Major Named[†] Wetlands in Study Area*

County	Wetland	Acres
Hillsborough	Williams Swamp	640
"	Moccasin Pond	375
"	Jerry Pond	75
"	Coleman Hammock	80
"	Chapman Hammock	60
"	Cabbage Hammock	65
"	Stallion Hammock	175
"	Hurrah Bay	150
"	Cypress Creek (headwater's)	
Polk	Green Swamp	
"	Hooker's Prairie (south to Whidden Creek)	4,500
Charlotte	Telegraph Swamp	
"	Rainey Slough	
Charlotte/DeSoto	Long Island Marsh	
DeSoto	Tippen Bay	
"	Sour Orange Hammock	
"	Tiger Bay	
"	Tiger Bay Slough	
"	Sheep Pen Marsh	
"	Long Point Marsh	
"	Oak Creek Marsh	
"	Buzzard Roost	
Manatee	Headwater, Manatee River	
"	Big Slough (headwaters)	
Hardee	Oak Creek	
"	Horse Creek Prairie	
"	Troublesome Creek (headwaters)	
	Lake Hancock	

[†] Many wetlands are unmaned, some of which are larger than those listed. See Volumes III and VI (Section 5) of these working papers for more information.

* SWFWMD (1975).

d. Lakes

Of the numerous lakes of various sizes within the study area, the majority are in Polk County (see Plate 1 in map pocket). Lake water-level fluctuations generally correspond with those of the local water table, but in some locations where a lake is directly connected with the aquifer through a sinkhole, the lake water level changes with fluctuations of the potentiometric surface of the Floridan aquifer (U.S. Army Corps of Engineers 1977). Lakes in the study area that are 100 acres or more in surface area are listed by county, surface area, drainage area, elevation, and type in Table 1.6. Such lakes represent approximately 2.0 percent of the study area's total surface area. No attempt was made to catalog the many other named and unnamed lakes in the study area; some are small sinkholes, while others are phosphate industry borrow pits and dammed or diked areas that have been developed as slime ponds to accept wastes from phosphate production (SWFWMD 1975). It is believed that acreages of lakes represent approximately 4 percent of the study area's surface area.

Also playing a hydrologic role in the surface-water system, but beyond the scope of this report, are canals, ditches, and channels. The U.S. Army Corps of Engineers (1977) reports that canals, ditches, and channels have been excavated in a number of locations in the study area, causing some natural drainage routes to be straightened and shortened and causing adjoining drainage basins to be connected in some locations. As examples, a canal diverts water from the Withlacoochee River (north of the study area) to the Hillsborough River during high flow, and the Tampa bypass canal now under construction will divert floodwaters from the middle reaches of the Hillsborough River in the vicinity of the cities of Tampa and Temple Terrace into the salty water of Hillsborough Bay. Many ditches and small bays extend inland from the Gulf Coast for short distances.

e. Streams in General

The highland ridge area of Polk County (belt of lakes and sinkholes) is the primary drainage divide not only for the study area but also for the entire state. Essentially, all water to the west of the ridge

Table 1.6. Lakes of More than 100 Acres in Study Area (Page 1 of 2)

County	Lake	Surface Area (acres)	Drainage Area (mi^2)	Elevation (ft)**	Type
Hardee	Horse Creek Prairie	162		57	Inflow/outflow
Charlotte	Jimlong	134		2	Inflow/outflow
Polk	Buffun	1,543		132	Inflow only
"	Noralyn Mine	180		128	Landlocked
"	Henry	106		159	Outflow only
"	Hancock	4,519	131.0	97	Inflow/outflow
"	Hamilton	2,162	20.5	120	Inflow/outflow
"	Eloise	1,160	3.4	131	Inflow/outflow
"	Fannie	829	23.7	125	Inflow/outflow
"	Garfield	655		100	Inflow/outflow
"	Eagle	651	2.5	131	Outflow only
"	Howard	628	1.2	131	Inflow/outflow
"	Rochelle	578	15.5	128	Inflow/outflow
"	Winterset	548	2.1	131	Inflow only
"	Annie	539		119	Inflow/outflow
"	McLeod	512	1.5	133	Landlocked
"	Sanitary	503	2.8	130	Outflow only
"	Hartridge	434	1.3	131	Inflow/outflow
"	Myrtle	413		118	Inflow/outflow
"	Little Lake Hamilton	367		120	Inflow/outflow
"	Cannon	336	10.1	131	Inflow/outflow
"	Lulu	301	20.5	131	Inflow/outflow
"	Surveyors	293		131	Landlocked
"	Shipp	283	14.9	131	Inflow/outflow
"	Smart	275	17.9	128	Inflow/outflow
"	Ruby	255		125	Inflow only
"	Connie	236	1.5	128	Inflow/outflow
"	Spirit	224		133	Landlocked
"	Gordon	213		114	Inflow/outflow
"	Lena	207		130	Inflow/outflow
"	Mariam	199		127	Inflow/outflow
"	Jessie	190	4.5	130	Inflow/outflow
"	Polk	186		109	Inflow only
"	Elbert	173		135	Landlocked
"	Eva	173		121	Outflow only
"	Crystal	158		121	Outflow only
"	Dexter	153		132	Landlocked
"	Bess	148		125	Inflow only
"	Star	147		108	Landlocked

* Florida Department of Environmental Regulation (1976a,b,c); SWFWMD (1975).

** Mean sea level.

Table 1.6 (Page 2 of 2)

County	Lake	Surface Area (acres)	Drainage Area (mi^2)	Elevation (ft)**	Type
Polk	Otis	143	1.0	128	Outflow only
"	Twin Lakes	143		113	Landlocked
"	Mountain	137	2.3	112	Landlocked
"	Tracy	136		124	Outflow only
"	Gun	162		132	Outflow only
"	Millsite	135		123	Inflow/outflow
"	Daisy	133		131	Landlocked
"	Deer	125	0.9	130	Landlocked
"	Mirror	123	0.5	131	Inflow/outflow
"	Parker	123		123	Landlocked
"	Rattle Snake	120		122	Landlocked
"	Mabel	117		108	Landlocked
"	Gator	114		130	Landlocked
"	Pembroke	110		109	Inflow/outflow
"	Middle Lake Hamilton	106		120	Inflow/outflow
"	Effie	102	2.5	117	Landlocked
"	Idelwild	102	6.2	131	Inflow/outflow
"	Deeson	117		184	Landlocked
"	Mud	133		138	Landlocked
"	Weohyakapka	7,552	93.5	62	Inflow/outflow
"	Marian	5,728	49.6	59	Inflow/outflow
"	Crooked	5,536	31.3	118	Inflow/outflow
"	Rosalie	4,595	133.0	53	Inflow/outflow
"	Arbuckle	3,789	170.0	53	Inflow/outflow
"	Pierce	3,738	58.9	76	Inflow only
"	Reedy	3,456	60.9	78	Inflow/outflow
"	Marion	2,970	35.7	67	Inflow/outflow
"	Tiger	2,202		50	Inflow/outflow
"	Livingston	1,203	87.0	87	Outflow only
"	Clinch	1,197	42.0	103	Landlocked
"	Scott	285		168	
Sarasota	Upper Myakka	975		18	Inflow/outflow
"	Lower Myakka	375	240.0	8	Inflow/outflow
Hillsborough	Thonotosassa	819	60.0	30	Inflow/outflow
"	Pleasant Grove Reservoir	850			
"	Wimauma	135		85	

drains into the Gulf of Mexico while all water to the east drains into the Atlantic Ocean. This ridge and sinkhole region of Polk County also has a pronounced effect on groundwater resources of the study area. Groundwater drainage in the area follows much the same pattern as that of surface drainage, i.e., the flow west of the ridge is into the Gulf while the flow east of the ridge is into the Atlantic (SWFWMD 1975). Many of the groundwater resources of the study area originate at the divide near the western edge of Polk County; for example, the Hillsborough and Peace rivers and their tributaries drain a large portion of the Green Swamp, a major water-conservation area in central Florida (U.S. Army Corps of Engineers 1977). Table 1.7 lists the major streams in the study area by county and includes the length and associated drainage area of each.

f. Flow Characteristics of Principal Streams

The principal streams in the study area are the Hillsborough, Alafia, Little Manatee, Manatee, Myakka, and Peace rivers (see Plate 1 in map pocket). Practically all of the surface drainage in the study area flows to the Gulf of Mexico.

Streamflow data have been collected for the study area's rivers and streams since the 1930s and have been supplemented since 1963 by a more complete network of stream-gaging stations. Records for all the sites measured since 1960 have been published in the USGS annual series of reports on Florida water resources, and records are published also every 5 years in the USGS water-supply papers ("Surface Water Supply of the United States: South Atlantic Slope and Eastern Gulf of Mexico Basins").

The operating USGS gages utilized for this report are listed in Table 1.8. The longest periods of record are 44 and 43 years at Arcadia (Peace River) and Lithia (Alafia River) respectively. Historical hydrographs for each major stream were prepared for the period of record and appear as Figure 1.6. From these hydrographs, it has been determined that the average flow from the major streams draining the 7-county study area for

Table 1.7. Major Streams in Study Area*

County	Stream	Length (mi)	Drainage Area (mi^2)	Flows into
DeSoto	Horse Creek	25.2	245.0	Peace River
"	Joshua Creek	11.7	134.0	Peace River
Charlotte	Shell Creek	13.3	297.0	Peace River
"	Prairie Creek	10.7	147.0	Shell River
"	Alligator Creek	7.6	44.5	Charlotte Harbor
"	Myakka River	54.1	540.0	Charlotte Harbor
Hardee	Charlie Creek	21.0	340.0	Peace River
"	Payne Creek	19.4	123.0	Peace River
"	Oak Creek	17.6	68.8	Charlie Creek
Polk	Bowlegs Creek	12.6	41.9	Peace River
"	Peace River (origin)	105.0	2,300.0	Charlotte Harbor
"	Peace Creek	11.1	160.0	Peace River
"	Saddle Creek	2.8	145.0	Peace River
Sarasota	Big Slough	25.0	99.0	Myakka
"	Phillipi Creek	13.2	55.0	Little Sarasota Bay
Manatee	Manatee River	–	350.0	Tampa Bay
Hillsborough	Alafia River	24.0	420.0	Tampa Bay
"	Bullfrog Creek	13.4	39.9	Tampa Bay
"	Southfork Little Manatee	8.6	39.0	Little Manatee River
"	North Prong Alafia River	17.8	140.0	Alafia River
"	South Prong Alafia River	25.8	135.0	Alafia River
"	Turkey Creek	8.4	42.7	Alafia River
"	Blackwater Creek	15.3	120.0	Hillsborough River
"	Hillsborough River	55.0	690.0	Hillsborough Bay
"	Cypress Creek	10.4	160.0	Thirteen Mile River
"	New River	9.7	19.0	Hillsborough River
"	Sweetwater Creek	10.4	25.0	Old Tampa Bay
"	Rocky Creek	11.0	45.0	Old Tampa Bay

*Florida Department of Environmental Regulation (1976b); SWFWMD (1975).

Table 1.8. Summary of Streamflow Characteristics (Period of Record)

Watershed	Gaging Station	Location	Years of Record	Drainage Area at Gage (mi²)	Total Basin or Sub-basin Area (mi²)	Flow of Record Mean (cfs)	Mean (mgd)	Max. (cfs)	Max. (mgd)	Min. (cfs)	Min. (mgd)	Avg at Mouth (cfs)	Avg at Mouth (mgd)	Remarks
Hillsborough River Basin					690									
Hillsborough River	02304500	City of Tampa dam	37 (10/39-9/76)	650		615	398	14,600 (3/21/60)	9,436	0 (11/30 & 12/2/45)	–	653	422	Water supply, City of Tampa
Six Mile Creek	–	S.R. 574	4	28	40	49	32	135	87	20	13	70	45	
Peace River Basin					2,403									
Peace River	02296750	Arcadia	44 (4/31-9/76)	1,367		1,195	772	36,200 (9/9/33)	23,396	37 (5/28/49)	24	2,100	1,357	
Horse Creek	02297310	10 mi from mouth	25 (4/50-9/76)	218		209	135	11,700 (8/11/60)	7,562	0				
Shell Creek	02298202	City of Punta Gorda dam	10 (1/65-11/76)	373		356	230	6,110 (6/28/74)	3,949	0				Water supply, City of Punta Gorda
Prairie Creek	0298123	4 mi downstream from Myrtle slough	14 (10/64-9/68, 10/69-current)	233		166	107	2,950 (7/74)	1,907	0 (6/3 & 7/65)				
Myakka River Basin					540									
Myakka River	02298830	36 mi from mouth	39 (8/36-1/77)	229		256	165	8,670 (8/1/60)	5,603	0		615	397	
Big Slough Canal	02299470	Murdock upstream from dam	9 (2/36-9/72	87.5	99	86.6	56	2,560 (7/31/65)	1,655	0		98	63	Water supply, North Port
Manatee River Basin					350									
Manatee River	02299950	Myakka head 36 mi from mouth	11 (5/66-9/76)	65.3		65	42	2,410 (8/31/72)	1,558	0.12 (5/24/75)	0.08	348	225	Water supply, Manatee County
Little Manatee River Basin					225									
Little Manatee River	02300500	Wimauma 15 mi from mouth	36 (3/39-9/76)	149		175	113	14,000 (6/11/60)	9,048	1.2 (6/6 & 4/75)	0.78	264	171	
Alafia River Basin					420									
Alafia River River	02301500	Lithia 16 mi from mouth	43 (10/33-1/77)	335		373	241	45,900 (9/9/33)	29,665	6.6 (6/5 & 7/45)	4	468	302	
Total						3,546	2,292	145,235	93,866	65	42	4,616	2,982	

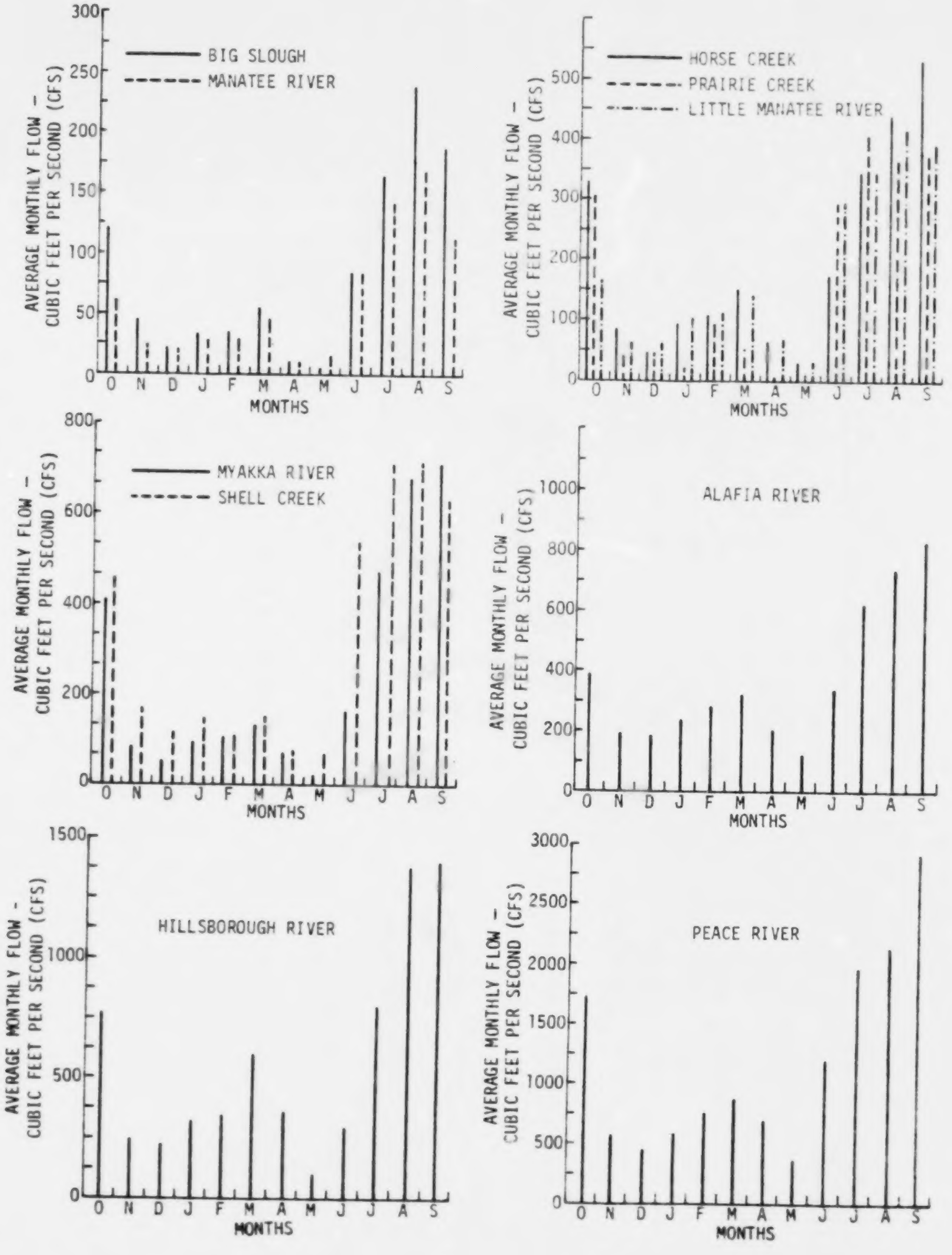


Figure 1.6. Hydrographs of Principal Streams in Study Area

which more than 5 years of records are available ranges from 65 cubic feet per second (42 million gallons per day) to 1,195 cubic feet per second (772 million gallons per day). The hydrographs indicate that low flows for the period of record occur from November through May, with March exhibiting the highest and May the lowest. The combined mean flows of the major streams total approximately 3,536 cubic feet per second (2,292 million gallons per day). The Peace and Hillsborough rivers account for approximately 51 percent of total flow, which is greater than the combined flows of all the remaining major streams in the study area. The flows from the Hillsborough and Alafia are the least variable, largely because they are fed by groundwater inflow from the Floridan aquifer. Flows throughout most of the remaining area are more variable because a large component of the flow is from overland runoff.

Although the average distance of even the smallest stream is sizable, a wide variation exists between maximum, average, and minimum discharge; and all of the streams except the Peace at Arcadia have exhibited little or no flow. Little or no flow will occur in all of the streams except Prairie Creek and the Peace River for as many as 30 consecutive days on the average once every 20 years. The average minimum 30-day low flow, which is expected to occur on the average once every 2 years, approximately equals the discharge equaled or exceeded 90 percent of the time. As a result of these low-flow characteristics, using the major streams for any sizable water supply would require that water be stored in a reservoir, the capacity of which would depend in part on the desired withdrawal rate.

In January 1976, the U.S. Corps of Engineers (Jacksonville District) initiated an intensive 9-month study in the Four River Basins area to determine ways in which excess surface or groundwater could be utilized to help solve regional water-supply problems. Part of the basic investigation included determination of such items as average, minimum, and excess flows of major streams within the study area over a 20-year period (1955-74). Average annual flows are presented in Table 1.9 and Figure 1.7.

Table 1.9. Average Annual Flows of Major Streams in Study Area, 1955-74*

Stream	Average Annual Flow at Mouth (cfs)	(mgd)
Alafia River	450	291
Hillsborough River	575	372
Little Manatee River	250	162
Manatee River	400	259
Myakka River	575	372
Peace River	2,000	1,293
Total	4,250	2,747

* U.S. Army Corps of Engineers (1977).

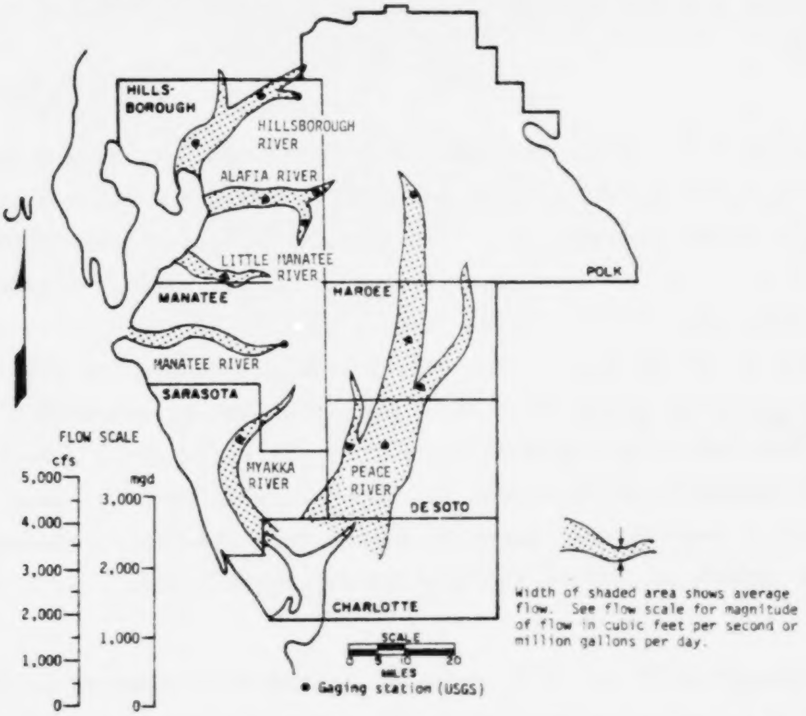

HILLS-
BOROUGH
HILLSBOROUGH RIVER
ALAFIA RIVER
LITTLE MANATEE RIVER
MANATEE
HARDEE
POLK
MANATEE RIVER
SARASOTA
MYAKKA RIVER
PEACE RIVER
DE SOTO
CHARLOTTE
N
FLOW SCALE
cfs
5,000
4,000
3,000
2,000
1,000
0
mgd
3,000
2,000
1,000
0
SCALE
0 5 10 20
MILES
● Gaging station (USGS)
Width of shaded area shows average flow. See flow scale for magnitude of flow in cubic feet per second or million gallons per day.

Figure 1.7. Average Annual Flows of Major Streams, 1955-74 (U.S. Army Corps of Engineers 1977)

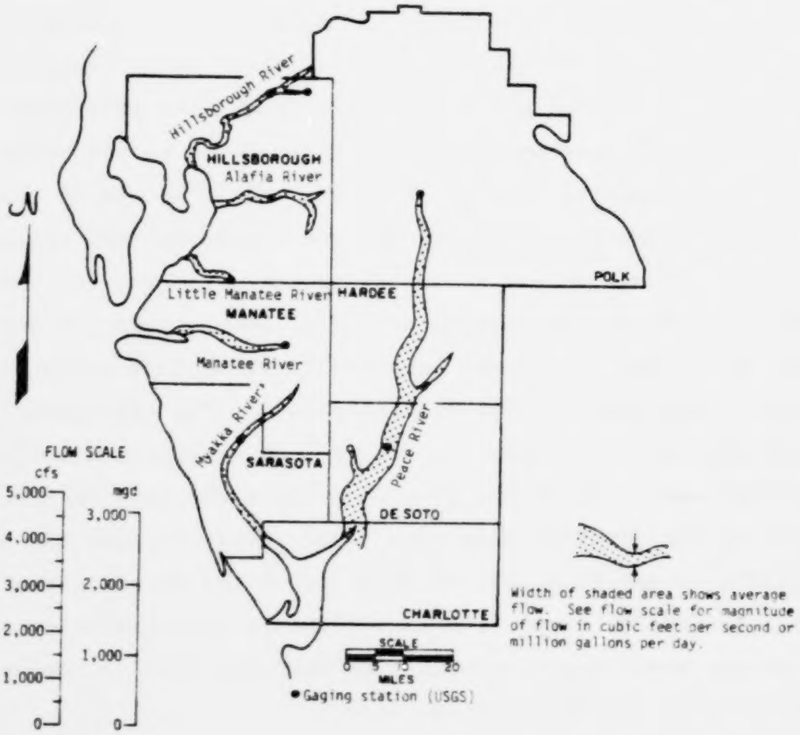
Comparing the previously mentioned period of record with the period used in the Four River Basins study, one sees that the average annual flow of the Peace River is approximately the same, whereas the Hillsborough River flow is higher and all other streams lower. Average flows for the 20-year period were compiled from USGS annual reports and utilized in combination with average annual minimum flows (Table 1.10 and Figure 1.8) to compute average annual excess flows (Table 1.11 and Figure 1.9). The data were used also to calculate the average annual runoff. On the illustrations, the widths of the shaded areas are proportional to the flow at any given point; a flow scale was used in determining the magnitude of flow in cubic feet per second or million gallons per day. The average annual minimum flow is the weighted average of the 12 monthly average minimum flow values. The combined average minimum flow of the major streams in the study area is 1,170 cubic feet per second, or 756 million gallons per day. Average excess flow (the difference between average flow and average minimum flow) approximates 3,080 cubic feet per second, or 1,991 million gallons per day - the amount of water potentially available for diversion assuming that no further legal or environmental constraints are implemented. The major excess flow (47 percent of the total) is from the Peace River. Combined, the Peace, Myakka, and Hillsborough rivers contribute approximately 77 percent of the total excess flow. According to the Four River Basins water resources management study (U.S. Army Corps of Engineers 1977), this type of information is useful only in the context of the overall water management evaluation; diversions at any one place will also impact the hydrology and biology of the streams, and contemplated diversions should be evaluated in detail in terms of environmental impacts to insure that they are in the public interest and will not significantly degrade the downstream ecology. Assuming that all the average annual excess flows are available for water supply and assuming an average per-capita demand of 160 gallons per day (SWFWMD's projection for the year 2000), the total excess flow could meet the requirements of approximately 12.4 million people. The Four River Basins study, however, indicates that the excess flow is poorly distributed in terms of both time and location and that there is a distinct lack of adequate surface storage facilities. Also, the relationship between the location of the available excess flow and the location of the demand centers must be evaluated; generally, population densities are relatively low in the coastal zone at points where major streams flow into the Gulf of Mexico (except near the mouth of the Hillsborough River).

To evaluate the temporal or seasonal distribution of excess flow, the long-term records (20 years or more) at four stream-gaging stations were

Table 1.10. Average Annual Minimum Flows of Major Streams in Study Area, 1955-74*

Stream	Average Annual Minimum Flow at Mouth (cfs)	(mgd)
Alafia River	190	123
Hillsborough River	125	81
Little Manatee River	60	39
Manatee River	130	84
Myakka River	115	74
Peace River	550	355
Total	1,170	756

* U.S. Army Corps of Engineers (1977).


Hillsborough River
HILLSBOROUGH
Alafia River
N
POLK
Little Manatee River
HARDEE
MANATEE
Manatee River
Myakka River
Peace River
SARASOTA
FLOW SCALE
cfs
5,000
4,000
3,000
2,000
1,000
0
mgd
3,000
2,000
1,000
0
DE SOTO
CHARLOTTE
SCALE
0
5
10
20
MILES
● Gaging station (USGS)

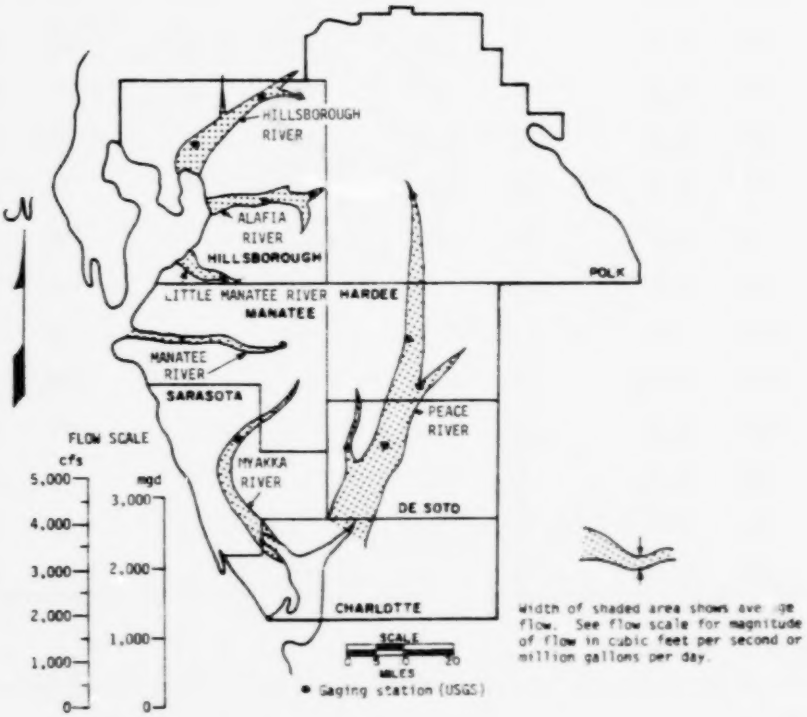
Width of shaded area shows average flow. See flow scale for magnitude of flow in cubic feet per second or million gallons per day.

Figure 1.8. Average Annual Minimum Flows of Major Streams, 1955-74 (U.S. Army Corps of Engineers 1977)

Table 1.11. Average Annual Excess Flows of Major Streams in Study Area, 1955-74*

Stream	Average Annual Excess Flow at Mouth (cfs)	(mgd)
Alafia River	260	168
Hillsborough River	450	291
Little Manatee River	190	123
Manatee River	270	175
Myakka River	460	297
Peace River	1,450	937
Total	3,080	1,991

* U.S. Army Corps of Engineers (1977).


N
HILLSBOROUGH RIVER
ALAFIA RIVER
HILLSBOROUGH
POLK
LITTLE MANATEE RIVER
HARDEE
MANATEE
MANATEE RIVER
SARASOTA
PEACE RIVER
MYAKKA RIVER
DE SOTO
CHARLOTTE
FLOW SCALE
cfs
5,000
4,000
3,000
2,000
1,000
0
mgd
3,000
2,000
1,000
0
SCALE
0 5 0 20
MILES
● Gaging station (USGS)

Width of shaded area shows average flow. See flow scale for magnitude of flow in cubic feet per second or million gallons per day.

Figure 1.9. Average Annual Excess Flows of Major Streams, 1955-74 (U.S. Army Corps of Engineers 1977)

analyzed. To facilitate comparison between river basins, the average monthly excess flow was converted to a flow rate per square mile of drainage (Table 1.12). Average monthly excess flows ranged from a low of 0.07 million gallons per day per square mile to a high of 1.51 million gallons per day per square mile of drainage area, both recorded at the gaging station on the Myakka River near Sarasota. Bartow on the Peace River was the gaging station with the least variability; average monthly excess flow ranged from 0.11 to 0.50 million gallons per day per square mile. Each year for 2-5 months, the average monthly excess flow at all four gaging stations equaled or was less than 0.2 million gallons per day per square mile.

Table 1.12. Monthly Excess Flow Characteristics at Selected Gaging Stations*

	Alafia River at Lithia ($DA^+ = 335\ mi^2$)		Hillsborough River at Zephyrhills** ($DA = 220\ mi^2$)		Peace River at Bartow ($DA = 390\ mi^2$)		Myakka River near Sarasota ($DA = 235\ mi^2$)	
Month	cfs‡	mgd/mi^2	cfs	mgd/mi^2	cfs	mgd/mi^2	cfs	mgd/mi^2
Jan	167	0.32	100	0.29	126	0.21	115	0.32
Feb	218	0.42	119	0.35	176	0.29	146	0.40
Mar	342	0.66	304	0.89	282	0.47	217	0.60
Apr	179	0.34	104	0.31	205	0.34	91	0.25
May	101	0.19	47	0.14	109	0.18	26	0.07
Jun	239	0.46	144	0.42	165	0.27	194	0.53
Jul	349	0.67	200	0.59	207	0.34	337	0.93
Aug	407	0.78	354	1.04	262	0.43	469	1.29
Sep	439	0.85	393	1.15	301	0.50	548	1.51
Oct	204	0.39	180	0.53	219	0.36	277	0.76
Nov	98	0.19	45	0.13	112	0.19	77	0.21
Dec	90	0.17	49	0.14	64	0.11	57	0.16
Annual avg	236	0.46	170	0.50	185	0.31	213	0.59

* U.S. Army Corps of Engineers (1977).

**Immediately north of study area but representative of Hillsborough River Basin.

+ Drainage area.

‡ 1 cubic foot per second = 0.6463 million gallons per day.

After comparing the average monthly flows for the period of record with the average minimum flows, it was concluded that some dry years had no excess flow or negligible excess flow for periods of up to 9 months. The records also indicated that excess flow may be available for only 8 to 15 percent of the time (i.e., 1-2 months) during low-flow periods extending to 13 months.

g. Runoff

Runoff is precipitation entering streams; it includes water that runs directly over the land surface to streams (surface-water component) and water seeping from aquifers into streams (groundwater component). The average annual surface-water runoff in inches per year is shown in Figure 1.10. The annual runoff ranges from approximately 4 inches to more than 20 inches. For the study area as a whole, the average runoff is about 11.5 inches. The highest runoff rates generally occur in urban areas such as Tampa, while lowest runoff rates occur in eastern Polk and northcentral Hillsborough counties.

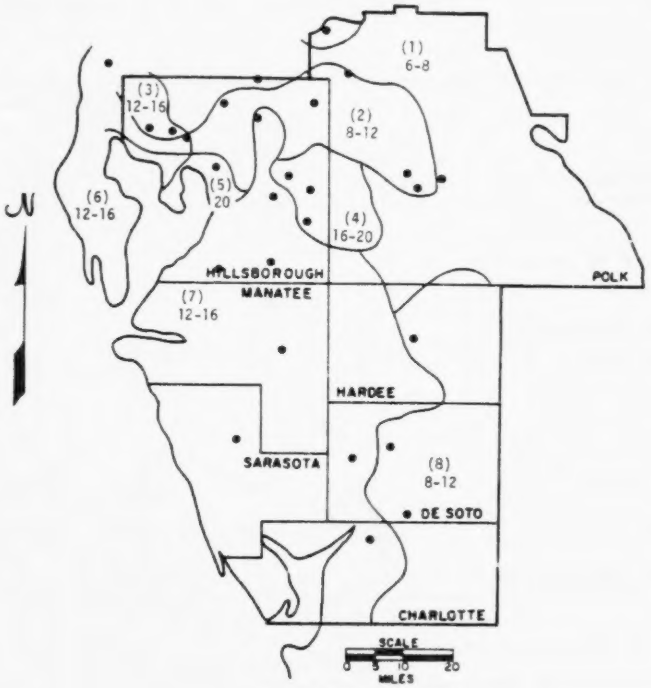

N
(1)
6-8
(2)
8-12
(3)
12-16
(4)
16-20
(5)
20
(6)
12-16
(7)
12-16
(8)
8-12
HILLSBOROUGH
MANATEE
POLK
HARDEE
SARASOTA
DE SOTO
CHARLOTTE
SCALE
0 5 10 20
MILES
• Gaging station (USGS).

Figure 1.10. Average Annual Runoff, 1955-74
(U.S. Army Corps of Engineers 1977)

h. Flood-Prone Areas

Floods, a combination of rainfall and runoff, are limited in this report to those designated by the U.S. Army Corps of Engineers as "intermediate regional" (one that could occur once in 100 years on the average, although it could occur in any year). A 100-year flood is one that has a 1-percent chance of occurring during any year (U.S. Army Corps of Engineers 1974).

Peak flows developed for the 100-year period and other intervals at selected locations in the study area are listed in Tables 1.13 and 1.14. The approximate 100-year flood-prone areas (only for the larger streams) are shown on Plate 2 (in map pocket), but actual limits may vary somewhat because the scale of the source maps does not permit precise plotting. Much of the area could be subject to shallow ponding or sheet flooding, but this is not indicated on the map.

Table 1.13. Estimated Peak Flows for Intermediate Regional Floods or 100-Year Floods for Upper Peace River Basin*

Location	Stream Mile**	Drainage Area (mi^2)	Intermediate Regional Flood Discharge (cfs)	(mgd)
Peace River				
Downstream of SR 60 bridge (USGS gage)	105.0	390	7,760	5,015
Upstream of confluence with Saddle Creek	106.2	220	4,540	2,934
Saddle Creek				
Upstream of confluence with Peace River	0	148	2,480	1,603
Structure P-11	2.3	135	2,040	1,318
Upstream of Lake Hancock	7.0	63	1,740	1,125

* U.S. Corps of Engineers (1974).

**Referenced from miles above mouth.

Table 1.14. Discharges at Gaging Stations and Mouth of Little Manatee River and Various Flood Frequencies*

Flood Return Interval (years)	Cubic Feet per Second per Square Mile		
	Mouth (DA** = 230 mi^2)	Station near Wimauma (DA = 149 mi^2)	Station near Fort Lonesome (DA = 31.4 mi^2)
100	32,590	18,500	2,510
50	26,070	14,900	2,065
25	19,780	11,560	1,684
10	13,426	7,930	1,230
Mean annual	5,251	3,300	605

* SWFWMD (1975).

** Drainage area.

i. Interrelationship of Ground Water and Surface Water

Because the shallow water-table aquifer is hydraulically connected to the lakes and generally discharges to them and, in turn, the lakes provide the base flow of the streams, the groundwater resources of the watershed are closely interrelated with the surface-water resources. There is evidence of this interrelationship in the fact that the base flow of nearly all the streams consists of seepage of water from both the Floridan aquifer (generally in the lower reaches of the streams) and from the water-table aquifer. Another indication of interconnection is from the results of studies of several streams in the Tampa Bay region (Cherry et al 1970) that suggest that withdrawals of ground water at major well fields can reduce streamflow (U.S. Army Corps of Engineers 1977). Such reductions may occur as a result of inducing water to move from the surface-water bodies into nearby aquifers or intercepting seepage that would normally move from the aquifers into the surface-water bodies; lake levels may be drawn down where heavy pumping of nearby wells reduces water-table levels.

4. Groundwater Resources

a. General Description of Groundwater System

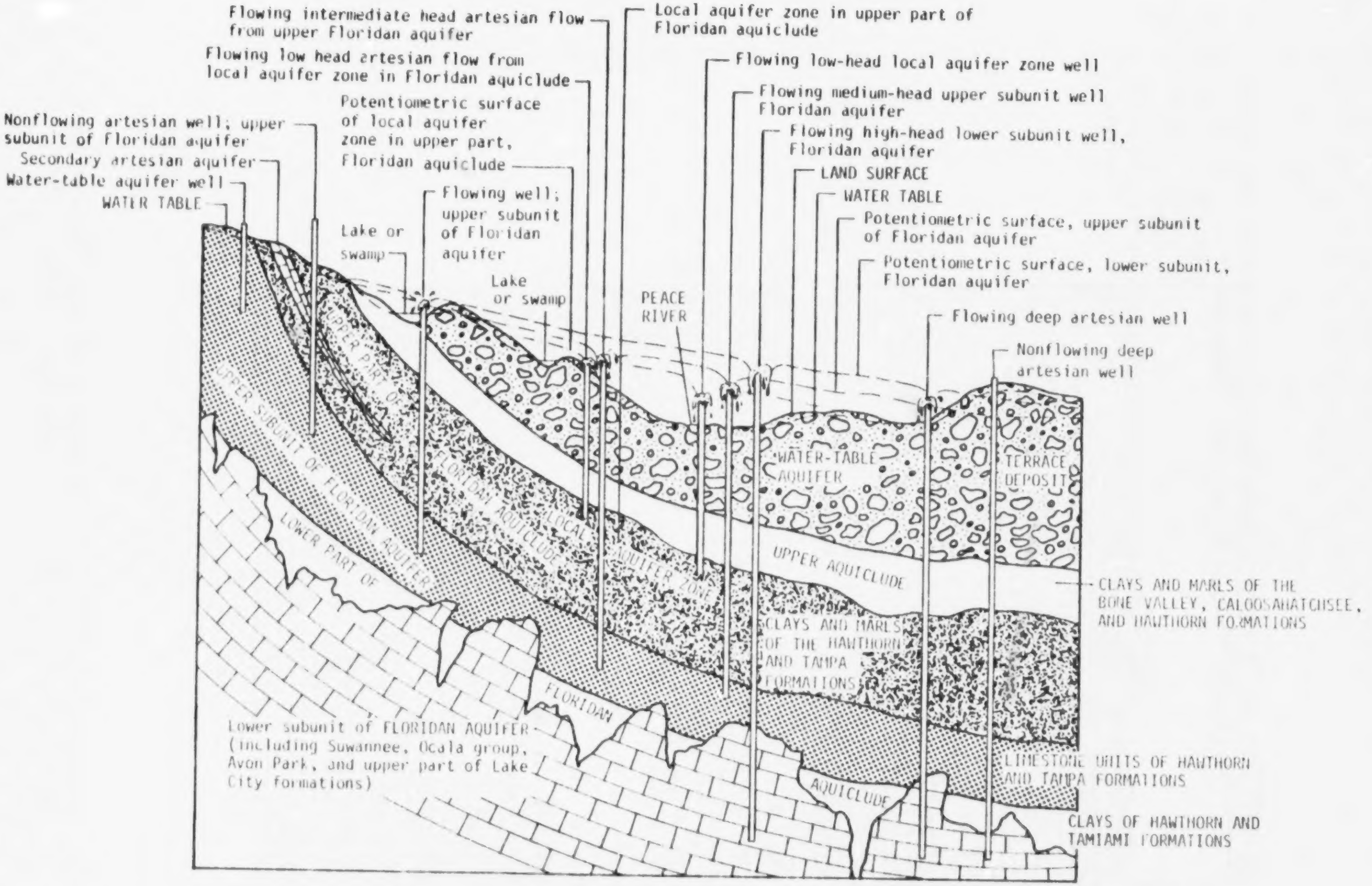
The groundwater system in the 7-county area is essentially a tripartite arrangement: the uppermost unit is a shallow, unconfined, sandy, marly water-table aquifer; a clayey unit that is thin in the north and thickens to the south is composed largely of the Hawthorn formation, Tampa limestone (clay), Bone Valley formation (clay and phosphate ores), Caloosahatchee marl (clay and marl), and Tamiami formation (clay); and the extensive and thick hydrologic unit, the Floridan aquifer (Parker 1951, Parker et al 1955), consists of two subunits, both primarily limestone and dolomite (Wilson 1975). In some areas, there are one or more aquifer zones well separated from the underlying Floridan aquifer. In Lee County south of the southern part of the study area, the Hawthorn formation has been divided into two aquifer zones which Sproul et al (1972) call the Upper Hawthorn and the Lower Hawthorn aquifers. In Charlotte County, five aquifer zones have been identified below the water-table aquifer (Sutcliffe 1975): zone 1 is a thin sandstone within the Tamiami formation; zone 2 is a sandy unit in the Upper Hawthorn and is equivalent to Stewart's "secondary artesian aquifer;" and zones 3, 4, and 5 are only upper parts of the Floridan aquifer. The latter are more or less separated locally by two calcareous and clayey confining beds and are the "minor aquifer zones" of this report.

The geologic structure of the area, the stratigraphic and hydrogeologic units, the water table, three potentiometric surfaces, and the relation of flowing and nonflowing wells to the land surface are shown in Figure 1.11, which displays a northeast-to-southwest section extending from the Green Swamp High to the western border of the Peace River drainage. Figure 1.12, an east-west hydrogeologic section through central Hardee County, illustrates the cavernous nature of the calcareous rocks that comprise the Floridan aquifer. The sections are mapped in Figure 1.13.

b. Water-Table Aquifer

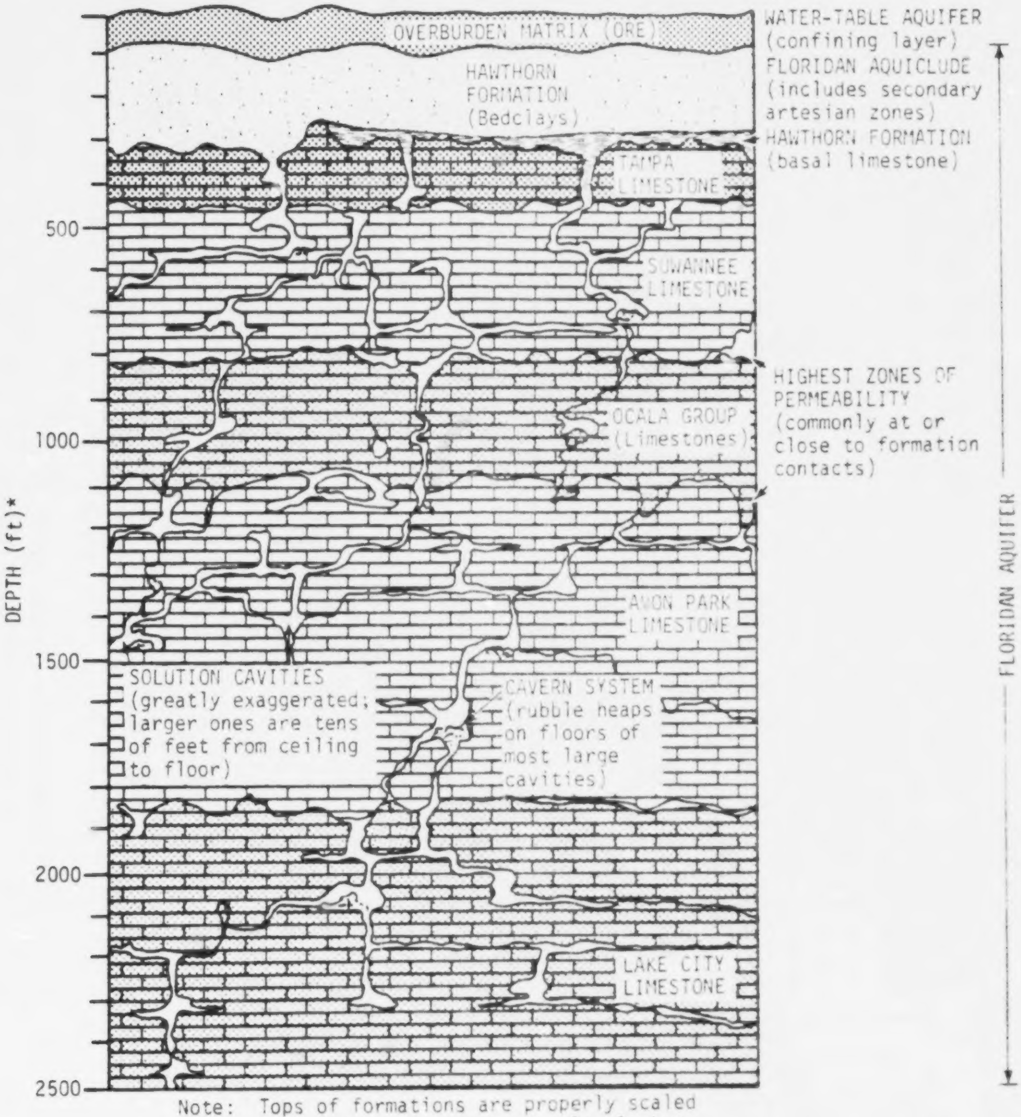
1) Materials

The water-table aquifer is a water-bearing formation composed chiefly of sand, silt, clay, and in places (particularly in southeastern Charlotte County) beds of shells and shell-marl. At and near its base, this shallow aquifer also includes the important commercial deposit of phosphate ore known as the Bone Valley formation (Table 1.15 and Figure 1.12).



Flowing intermediate head artesian flow from upper Floridan aquifer
Flowing low head artesian flow from local aquifer zone in Floridan aquiclude
Local aquifer zone in upper part of Floridan aquiclude
Flowing low-head local aquifer zone well
Flowing medium-head upper subunit well Floridan aquifer
Flowing high-head lower subunit well, Floridan aquifer
LAND SURFACE
WATER TABLE
Potentiometric surface, upper subunit of Floridan aquifer
Potentiometric surface, lower subunit, Floridan aquifer
Flowing deep artesian well
Nonflowing deep artesian well
Nonflowing artesian well; upper subunit of Floridan aquifer
Secondary artesian aquifer
Water-table aquifer well
WATER TABLE
Potentiometric surface of local aquifer zone in upper part, Floridan aquiclude
Flowing well; upper subunit of Floridan aquifer
Lake or swamp
Lake or swamp
PEACE RIVER
WATER-TABLE AQUIFER
TERRACE DEPOSIT
UPPER AQUICLUDE
CLAYS AND MARLS OF THE BONE VALLEY, CALOOSAHATCHEE, AND HAWTHORN FORMATIONS
CLAYS AND MARLS OF THE HAWTHORN AND TAMPA FORMATIONS
LIMESTONE UNITS OF HAWTHORN AND TAMPA FORMATIONS
CLAYS OF HAWTHORN AND TAMIAMI FORMATIONS
UPPER PART OF
FLORIDAN AQUICLUDE
LOCAL AQUIFER ZONE
UPPER SUBUNIT OF FLORIDAN AQUIFER
LOWER PART OF
FLORIDAN
AQUICLUDE
Lower subunit of FLORIDAN AQUIFER (including Suwannee, Ocala group, Avon Park, and upper part of Lake City formations)

Figure 1.11. Idealized Northeast-Southwest Hydrogeologic Section from Green Swamp High near Lake Wales to Western Border of Peace River Drainage through Central Florida Phosphate District (prepared by Geraghty & Miller, Inc.)


OVERBURDEN MATRIX (ORE)
HAWTHORN FORMATION (Bedclays)
TAMPA LIMESTONE
SUWANNEE LIMESTONE
OCALA GROUP (Limestones)
AVON PARK LIMESTONE
LAKE CITY LIMESTONE
SOLUTION CAVITIES (greatly exaggerated; larger ones are tens of feet from ceiling to floor)
CAVERN SYSTEM (rubble heaps on floors of most large cavities)
WATER-TABLE AQUIFER (confining layer)
FLORIDAN AQUICLUDE (includes secondary artesian zones)
HAWTHORN FORMATION (basal limestone)
HIGHEST ZONES OF PERMEABILITY (commonly at or close to formation contacts)
FLORIDAN AQUIFER
DEPTH (ft)*
500
1000
1500
2000
2500

Note: Tops of formations are properly scaled with reference to mean sea level, but drawing otherwise is not to scale.

Figure 1.12. Idealized East-West Hydrogeologic Section through Central Hardee County (prepared by Geraghty & Miller, Inc.)

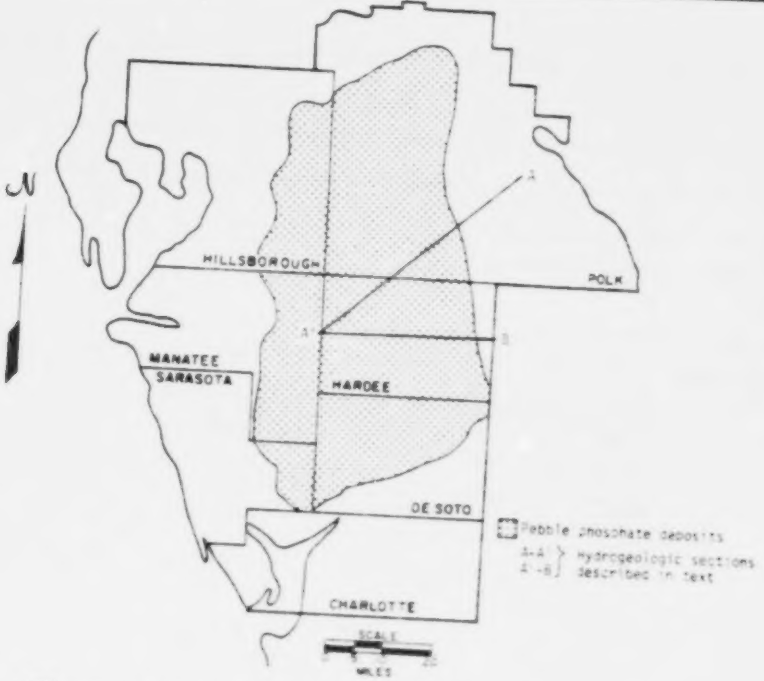

N
HILLSBOROUGH
POLK
A
A'
B
MANATEE
SARASOTA
HARDEE
DE SOTO
CHARLOTTE
Pebble phosphate deposits
A-A' } Hydrogeologic sections
A'-B } described in text
SCALE
MILES

Figure 1.13. Locations of Hydrologic Sections (modified from Wright 1974)

2) Areal Extent and Thickness

The water-table aquifer covers the entire 6,242 square miles of the report area and ranges in thickness from less than 25 feet in coastal Manatee County to more than 100 feet along the hydrologic divide between the drainage basins of the Peace and Kissimmee rivers. The uppermost beds over most of its extent are permeable sand.

In the poorly drained areas, the water table is near or at the land surface and the gradient generally is fairly flat. In the better drained parts of the region, the water table, or upper surface of the zone of saturation, may be approximately 5 to 30 feet below land surface and the gradients are generally steeper. This is shown in Plate 3 (map pocket), which portrays the approximate water-table contours in feet above mean sea level. The altitudes of the water table were estimated from 7.5 degree topographic quadrangle maps prepared and revised by the USGS; the values were checked, where possible, with actual water-level measurements, but the

Table 1.15. Hydrogeologic Section, Central Florida Phosphate District

System	Series	Formation	Characteristics	Hyd. Unit	Thickness (m)	Thickness (ft)
Quaternary	Holocene		Soil, muck, marl, alluvium, sand	Water-table aquifer	0-6.1	(0-20)
	Pleistocene	Pamlico sand	Sand, shells, limestone		0-6.1	(0-20)
		Anastasia formation	Limestone, sandstone, shells		0-3	(0-10)
		Older terrace deposits	Sand		0-18.3	(0-60)
Tertiary	Pliocene	Caloosahatchee marl	Marl, sand and gravel of quartz and phosphate; shells; bone fragments		0-3	(0-15)
		Bone Valley formation	Sand and gravel of quartz and phosphate; clay; bone fragments	Upper aquiclude	0-9.1	(0-30)
	Miocene	Hawthorn formation	Clay and marl: gray, greenish, and bluish gray; sandy, phosphatic, calcareous. Interbedded with sandy limestone, silt, sand, and shells. The sand, shell, and limestone beds are the source of small water supplies. The water in the Hawthorn formation is under artesian pressure and is generally less mineralized than the water in the Tampa and older formations.	Minor aquifer	45.7-109.7	(150-360)
		Tampa limestone	Limestone: white, gray, and tan, generally hard, dense sandy, phosphatic in part, silicified in part, fossiliferous. Porosity due primarily to solution cavities. In east and south, very clayey. Limestone yields large quantities of artesian water.	Floridan aquiclude	38.1-71.6	(125-235)
	Oligocene	Suwannee limestone	Limestone: creamy white and tan; soft to hard, granular, porous; crystalline, dolomitic in part, very fossiliferous. Generally, a more productive source of artesian water than the Tampa, but somewhat more mineralized.	Floridan aquifer	45.7-91.4	(150-300)
	Eocene	Ocala group (Crystal River, Williston, and Inglis limestones)	Limestone: white, cream, tan, chalky, soft, granular, and porous; coquinoid in part, with some hard, dense layers and some thin beds of brown, crystalline dolomite. Generally, a productive source of artesian water, but parts are chalky and of low permeability. Water is relatively high in mineral content in the coastal area.		91.4-99.1	300-325
		Avon Park limestone	Limestone: cream, tan, and brown, soft to hard, granular and coquinoid in part, crystalline and dolomitic in part, very porous. A very productive source of water, particularly in the dolostone units. Water is high in mineral content in the coastal area. Generally, high SO_4 in deeper parts of the formation everywhere.		213.4	700
		Lake City limestone	Limestone: cream and tan, chalky to granular; dolomitic and gypsiferous in part and some fossiliferous in part. Water is highly mineralized in south and west.	Salaquifer	152.4	500
		Oldsmar limestone	Limestone: tan and brown, granular, porous, interbedded with chert, anhydrite, and tan-to-brown crystalline porous dolomite. Water highly mineralized.		289.6	950
	Paleocene	Cedar Keys formation	Limestone: cream to tan, fairly hard, granular, gypsiferous, interbedded with tan-to-brown crystalline dolomite, fossiliferous in part. Water very salty.		609.6	2,000
Cretaceous	Gulf		Limestone, shale, anhydrite. Water very salty and briney.			

nature of the available data is such that the values of the contours shown on the map are only approximate, with those in the flatlands being more reliable than those in the upland areas.

When rain falls on the sandy land surface of the upland areas, the water is quickly absorbed and little or no overland flow occurs over hundreds of square miles in the Central Florida Phosphate District; in contrast, there is little absorption of the rainfall in the flatland areas where the water table is high. This results in substantial amounts of overland runoff, which shows as peak flows of large magnitudes in the major streams.

3) Hydrologic and Water-Supply Characteristics

The water-table aquifer is a leaky receptacle that receives and stores water and also transmits it wherever a sufficient gradient exists. Thus, by discharging into streams, lakes, and swamps, the water-table aquifer helps to maintain the permanence of these natural surface-water bodies.

Historically, the water-table aquifer has been the source of many thousands of shallow wells that are the sole sources of water for the culinary, stock-watering, and irrigation needs of rural homes and small villages; in some coastal areas and larger islands off the Gulf Coast, many families still obtain household water supplies from shallow wells completed in the water-table aquifer. The yield of such wells varies from a few to up to several hundred gallons per minute, and the quality of the water is generally good to excellent although in some areas the iron content is high enough to stain porcelain, painted walls, concrete driveways, and clothing. In recent years, the trend has been to abandon this shallow source of supply and to depend on wells completed in either the minor artesian aquifers or the Floridan.

The water-table aquifer's current main function is to store water and to supply recharge to the underlying minor artesian aquifers and to the

Floridan aquifer and to maintain the dry-weather flow of the streams or canals that cut into it. Port Charlotte's water supply, for example, is derived largely from the Yale and Fordham waterways, which connect with the Cocoplum waterway, which in turn taps the Big Slough canal. Other municipal systems derive their supplies from the west branch of Coral Creek near Placida, from the Manatee and Braden rivers near Bradenton, and from Shell Creek near Punta Gorda.

The quality of the water in the water-table aquifer has been deteriorated over wide areas by saltwater encroachment directly from the Gulf of Mexico - primarily from dug and dredged channels and from saline springs such as Warm Mineral Spring and Little Salt Spring. Also, numerous abandoned wild-flowing deep artesian wells have contributed to the contamination of the water-table aquifer; highly mineralized ground water has leaked upward from the Lower Floridan aquifer, also contaminating the freshwater zones in the upper Floridan.

In addition to the above-named public-supply streams that derive their base flows from the water-table aquifer, several other streams could be similarly developed - the Myakka River, Horse Creek, Myrtle Slough, Alligator Creek, and the Peace River.

4) Hydraulic Characteristics

The principal hydraulic characteristics of an aquifer are its capacities to transmit water ("hydraulic conductivity or transmissivity") and to store water.

Transmissivity is the rate at which water is transmitted through the entire thickness and unit width of the aquifer under a unit hydraulic gradient and under the prevailing kinematic viscosity. Values are largely controlled by the aquifer's fabric, i.e., the skeletal arrangement of solid particles and the sizes and shapes of the particles and voids between them. In the water-table aquifer of the Central Florida Phosphate District (Figure 1.13), transmissivity values determined from both field and laboratory tests range from less than 1,000 to more than 5,000 gallons per day per foot; the average may be about 3,000-4,000.

The aquifer's storage coefficient is the volume of water released from storage in a vertical column of 1 square foot when the water table (or potentiometric surface) declines 1 foot. In a water-table (unconfined) aquifer, it approximates the specific yield. In the Central Florida Phosphate District, it ranges from approximately 0.015 to about 0.35; the average may be about 0.15.

5) Flow Regime

The flow regime of an aquifer describes the balance that exists between recharge to it, storage in it, and discharge from it. In its undisturbed or natural state, the aquifer is kept constantly full above its lowest levels of discharge; however, when drainage or pumping removes more water than nature returns, the water table or potentiometric surface falls, storage is diminished, and it is said that the aquifer is being "mined."

a) Recharge and Storage

Rainfall in the Central Florida Phosphate District is about 55 inches annually and is the source of all aquifer recharge in the area. In the study area, streams are gaining, not losing, water. Shortly after a rainstorm, the water table rises as rainwater percolates downward and adds to the aquifer's charge of water already in storage. A 1-inch recharge will raise the water table 5 inches in an aquifer having an effective porosity of 0.20 and about 6.7 inches in an aquifer with a 0.15 effective porosity. Normally over a period of many years under natural, undeveloped conditions, recharge will occur often enough to keep the aquifer full to overflowing. Each year's recharge in the Central Florida Phosphate District ranges from about 0.5 to 1.0 inch out of the 55 inches of annual precipitation over the area; of the remaining 54 inches, 37 to 40 inches are lost to evaporation and 14 to 17 inches run off as surface-water flow. (See subsection B.2 for a discussion of these relationships).

Water "stored" in an aquifer is seldom still but is constantly moving from places of recharge to places of discharge; nevertheless, the quantity in storage at any one time or place may be calculated or reasonably estimated. For example, in a segment of the water-table aquifer having a 0.15 storage coefficient (effective porosity) and saturated dimensions of 1 mile square and 10 feet deep, approximately 313 million gallons of water would be stored; and for an average depth of 50 feet, the aquifer would store 1.565 billion gallons. Over the 6,242 square miles of the study area, the quantity of water held in storage in this shallow aquifer would be about 9.77 trillion gallons.

b) Discharge

Discharge, or loss from the aquifer, occurs through several means including seepage and spring flow into rivers, lakes, ponds, swamps, marshes, and directly to the Gulf of Mexico along the shoreline. The water-table aquifer also loses large quantities by evaporation from wetland areas where, by capillary action, water rises to the land surface and evaporates directly into the air. Additionally, plant roots reaching deeply enough "pump" water into the plant (a tree, shrub, grass, etc.), and thus the aquifer loses water to the combined natural loss called evapotranspiration (explained previously in this section).

Ground water flows in the direction of the water-table gradient according to Darcy's law, which may be stated as $Q = TIL$ where Q is the flow in gallons per day, T is the transmissivity in gallons per day per foot, I is the gradient or slope of the water table in feet per mile, and L is the width of the line in miles across which flow takes place. Near streams and pumping wells, the gradient steepens and the flow accelerates. In the flat interstream areas of the study area, the gradients tend to be very low; therefore, flow is very slow. As an example, flow would equal 9,750 gallons per day in an interstream flatland area where the transmissivity was 650 gallons per day per foot, the slope of the water table was 1.5 feet per mile, and the width of the line of discharge into a stream was 10 miles; in an area of considerable relief where gradients were on the order of 10 feet per mile, transmissivity was 12,500, and the width of the line of discharge was

10 miles, flow would equal 1.25 million gallons a day. In the study area, such ranges in discharge in different parts of the water-table aquifer are not unusual.

c) Seasonal and Long-Term Fluctuations

The water table represents the upper level of saturation in an unconfined aquifer and is an air/water contact surface. It stands higher above sea level beneath uplands than beneath lowlands and generally reflects in a subdued fashion the topography of the land surface. With the onset of the rainy season (generally in June), the water table begins its seasonal rise, which ordinarily reaches its maximum in October. With the cessation of the rainy season, the water level begins to decline and commonly reaches its lowest stage in May. At or near the shoreline of the Gulf of Mexico, there is little water-table fluctuation (less than a foot); inland, however, the amplitude of the seasonal fluctuation increases until it reaches a maximum of approximately 5 to 10 feet. These fluctuations represent actual storage changes in the water-table aquifer. As an average, when the water table falls 12 inches, about 2.5 inches of stored water has been lost. Generally, a rise of 12 inches increases the storage by approximately 2.5 inches; this amount of water gained or lost represents a change in water-table storage of about 43.5 million gallons per square mile.

Over the Central Florida Phosphate District as a whole, long-term changes in water-table levels have occurred only in the coastal marshes and inland swamps and lakes and surrounding adjoining areas where large-scale drainage operations or navigation canals and mosquito-control ditches have been undertaken. In such areas, seasonal changes can range from a few centimeters to a few meters; in the main, however, these fluctuations simply take place from a lowered base level.

Water-table levels may be permanently lowered also in and surrounding major well fields; the water table would rise and fall with considerable lag as the potentiometric surface rose and fell in response to well pumping.

c. Minor Artesian Aquifers and Subdivisions

1) Materials

Low-pressure artesian aquifers and aquifer zones have been known for many years in Florida and are generally assigned to various Miocene-age formations, particularly the Hawthorn which consists of up to several hundred feet of stratified and interbedded layers and lenses of clay, sand, clay-marl, shell marl, and sandy, phosphatic limestone (Figure 1.11 and Table 1.15). The confined ground water in the more permeable parts of the Hawthorn formation is the generally good-quality water furnished to the numerous small-diameter wells drilled to these low-pressure aquifers or aquifer zones.

2) Areal Extent and Thickness

The "secondary artesian aquifer" was first described as being composed of limestone members of the Hawthorn formation in Polk County (Stewart 1966). The limestone members are confined from above by either clay in the upper part of the Hawthorn formation or clay in the lower part of the Bone Valley (the phosphatic ore-bearing) formation and are confined from below by blue clay beds of the Tampa formation. The aquifer is about 10 feet thick and extends throughout much of Polk County south of Dade City, which is near the crest of the Green Swamp High in the northern part of Polk County. The "secondary artesian aquifer," or its equivalent, is now found throughout much of southern Florida by several different names (e.g., "Miocene aquifer," Parker et al 1955; "Hawthorn," Stringfield 1933; "Hawthorn," Peek 1958; "shallow artesian aquifer," Klein 1954; "Upper Hawthorn, zone 2" and "Lower Hawthorn, zone 3," Sutcliffe 1975; and "Upper Hawthorn aquifer" and "Lower Hawthorn aquifer," Sproul et al 1972). Sproul et al (1972) show it (their Upper Hawthorn aquifer) to have thickened from its 10-foot thickness in the Green Swamp area to about 145 feet in western Lee County, a distance of some 85 miles; they also note a Lower Hawthorn aquifer about 190 feet thick, which includes the basal Hawthorn and Upper Tampa limestone and is actually the uppermost part of the Floridan aquifer which, by definition (Parker 1951), includes permeable parts of the Tampa and Hawthorn formations that are in hydraulic contact with the rest (deeper parts) of the aquifer.

3) Hydrologic and Water-Supply Characteristics

In the northern part of the Central Florida Phosphate District, the "secondary artesian aquifer" is used chiefly for small supplies to households and for stock-watering; however, some wells that terminate in limestone cavities and yield as much as 600 gallons per minute are used for irrigation. The average yield is approximately 35 gallons per minute.

Farther south in Sarasota, Hardee, DeSoto, and Charlotte counties where the Floridan aquifer naturally bears saline ground water in concentrations up to 1,000 milligrams per liter (Figure 1.14), the "secondary artesian aquifer" loses its identity and becomes the Upper Floridan aquifer (Wilson 1975); its water is commonly used for all purposes including municipal, self-supplied industrial, and agricultural. The Upper Floridan in these lower counties yields 10 to 30 gallons per minute to thousands of small-diameter wells and up to 250 gallons per minute to some of the larger-diameter wells for most municipal water supplies and irrigation. It also provides brackish water to some of the offshore islands and to the coastal zone where users desalinate the water in reverse-osmosis or electrodialysis plants. Such communities include Siesta Key, Rotunda West, Venice, Port Charlotte, Punta Gorda, Pine Island, Sanibel, and Cape Coral. In some of these communities salinity is increasing with continued pumping from the aquifer, thus creating operational and financial problems for plants not designed to handle increased salinity.

Only a few pumping tests have ever been run on the Upper Floridan aquifer. Clark (1964) describes three such tests made in Venice, Florida. Transmissivity values were 5,600; 6,100; and 8,500 gallons per day per foot. Storage coefficients were 8.7×10^{-5}. 1.1×10^{-4}, and 1.3×10^{-4}, while values of leakance were 1.3×10^{-3}, 1.4×10^{-3}, and 7×10^{-3} gallons per day per foot.

Inasmuch as potentiometric pressures are greater in the Lower Floridan aquifer than in the Upper Floridan aquifer, which in turn has greater pressures than the water-table aquifer, leakance takes place from the deeper to the shallower aquifers. However, the cones of depression

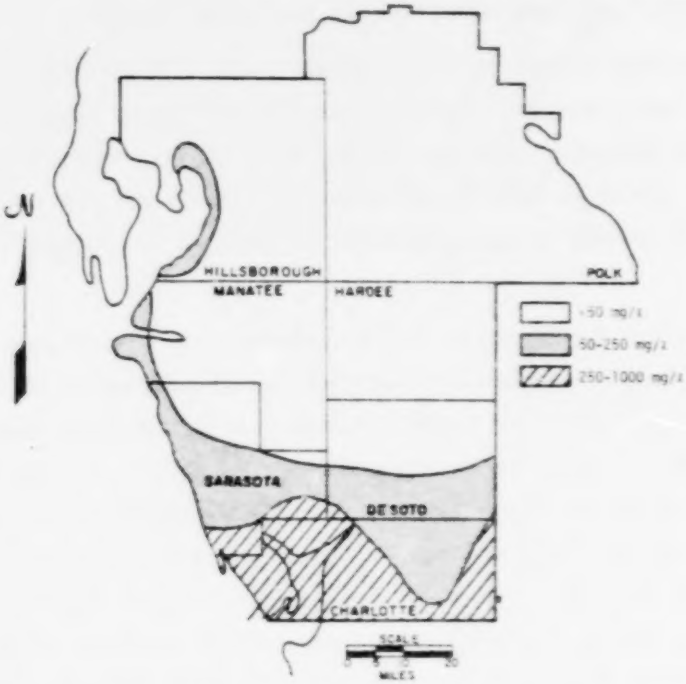


Figure 1.14. Chloride in Upper Floridan Aquifer (U.S. Army Corps of Engineers 1977)

produced by large-scale pumping of the Lower Floridan aquifer in much of the area have lowered the potentiometric surface of the Lower Floridan to such an extent that there is a reverse, or downward, leakance. In the Central Florida Phosphate District, this is especially important where agriculture and the phosphate industry pump many millions of gallons a day from the Suwannee-Ocala-Avon Park formations.

Leakance also occurs on a grand scale through the thousands of wells drilled to depths of approximately 500 to 1,500 feet; since most of the boreholes are either uncased or have casing that is rusted and corroded, outward flow occurs, carrying the deep, saline, high-pressure water into the low-pressure aquifers above. In some localities, the natural separations that originally existed between the shallow freshwater aquifers and the deeper saltwater aquifer or aquifer zones now are essentially nonexistent; man has created so many artificial connections by means of poorly cased or rusted-out well casings that an effective hydraulic connection now exists from top to bottom of the aquifer system in those areas.

4) Flow Regime

Unfortunately, the data base for recharge, storage, discharge, and water-level fluctuations, especially for the water-table and shallow aquifers or aquifer zones above the Floridan in the southwest Florida area, is poor. Until much-needed, systematic, comprehensive water-resources studies are made over the entire area, a great deal of estimating is necessary.

a) Recharge and Storage

Recharge to the Upper Floridan aquifer is generally best in the higher interior areas that are a score or more miles inland from the coast and away from the tidal streams. In these interior areas, recharge is good to excellent where the water-table aquifer lies directly upon the Upper Floridan and little or no confining materials separate them. Where an effective aquiclude separates the water-table aquifer from the Upper Floridan aquifer and the latter's potentiometric surface is higher than the water table, recharge moves the other way, i.e., upward from the Upper Floridan to the water-table aquifer; and the same situation exists for the Lower Floridan. The quantities involved in either upward to downward recharge can be calculated for specific areas if the pertinent hydrologic factors are known, but to try to estimate them in this report for the Central FLorida Phosphate District as a whole (or even by subareas) is not only impossible but would be misleading.

While storage in the Upper Floridan is generally quite low per unit area, it is substantial over the 6,242 square miles of the study area. Assuming that the range in the coefficients of storage of this low-pressure artesian system is on the order of 1×10^{-3} to 4×10^{-5} and that the average thickness of the aquifer is approximately 80 feet, the total estimated volume of water stored may range between 4.2 and 104 billion gallons.

b) Discharge and Potentiometric Fluctuations

The Upper Floridan aquifer discharges to the overlying water-table aquifer where the water table stands lower than the potentiometric surface; to streams, lakes, and ponds or marshes where the potentiometric surface stands above the water levels of these surface-water bodies; to deep pits and ponds that are excavated into or through the Upper Floridan; and to springs or wells. It also discharges downward where the potentiometric surface of the Lower Floridan aquifer has been drawn down by heavy pumping. No quantitative evaluations of ground water discharged from the Upper Floridan have been made (except in local well-field studies).

Although no potentiometric maps of the Upper Floridan aquifer exist except for a few small areas (Stewart 1959), it is known that water levels in wells penetrating this aquifer generally stand 1 to 2 feet above the water table and that seasonal high and low fluctuations of the potentiometric surface occur, rather closely following water-table fluctuations; however, little data exist to substantiate these fluctuations. It seems reasonable to estimate a 3- to 5-foot normal fluctuation of the potentiometric surface in nonpumping areas, because the same fluctuations occur in the water-table aquifer.

d. Floridan Aquifer System

The Floridan aquifer system is basically bipartite, i.e., composed of two principal but intimately related and functioning hydrologic units: the Floridan aquiclude, which acts as a lid or confining cap to the underlying aquifer and by its presence allows the development of artesian conditions in the aquifer (Parker 1951, Parker et al 1955) and the Floridan aquifer, which stores and transmits water, generally under artesian (confined) conditions. The hydrogeologic sections depicted in Figures 1.12 and 1.13 illustrate the relationship. Figure 1.15 is a contour map of the top of the Floridan aquifer, which is also the floor or base of the Floridan aquiclude.

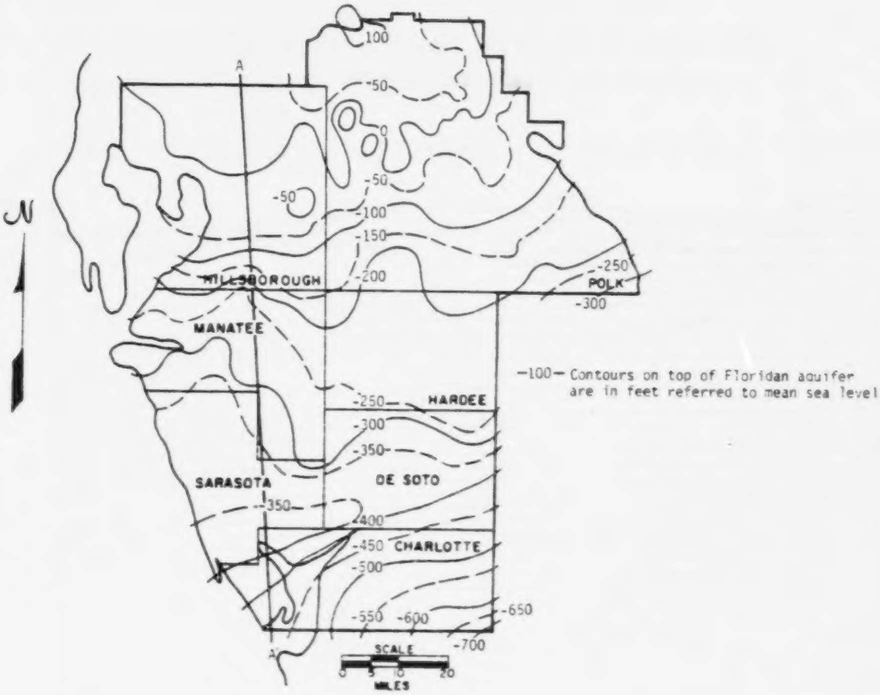

N
100
A
-50
0
-50
-50
-100
-150
-200
HILLSBOROUGH
-250
POLK
-300
MANATEE
—100— Contours on top of Floridan aquifer are in feet referred to mean sea level
-250
HARDEE
-300
-350
SARASOTA
DE SOTO
-350
-400
-450
CHARLOTTE
-500
-550
-600
-650
-700
A'
SCALE
0 5 10 20
MILES

Figure 1.15. Contours on Top of Floridan Aquifer, North-South Hydrogeologic Section Showing Aquifer-Aquiclude Relationships (U.S. Army Corps of Engineers 1977)

1) Floridan Aquiclude

The Floridan aquiclude (Figure 1.16) is the relatively impermeable or poorly permeable cap that permits artesian conditions to occur in the underlying Floridan aquifer (Parker 1951, Parker et al 1955). It is composed primarily of clays and marls of several different formations. In the study area, its principal components are the Hawthorn formation and clays and marls of the Tampa limestone, Tamiami formation, and Caloosahatchee marl. It is thin in the north in the study area and totally missing in the western part of the Green Swamp High in northwestern Polk County; however, it rapidly thickens southward, reaching thicknesses of approximately 600 feet in southeastern and 400 feet in northwestern Charlotte County (Vernon 1973).

The fine-grained, layered, detrital material of clay, silt, marl, and fine to very fine sands that comprises the bulk of the Floridan

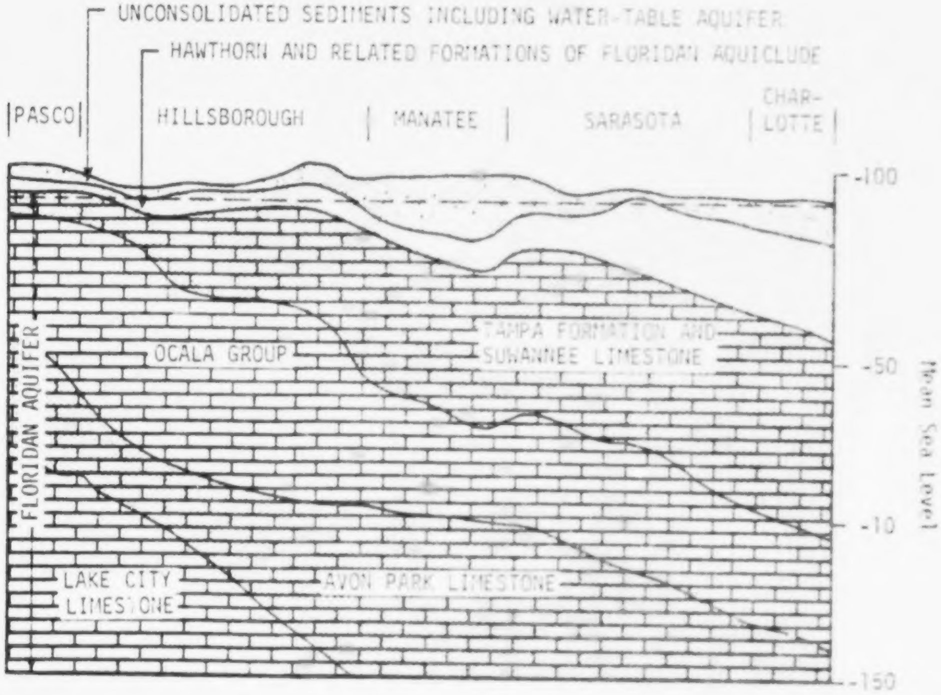

UNCONSOLIDATED SEDIMENTS INCLUDING WATER-TABLE AQUIFER
HAWTHORN AND RELATED FORMATIONS OF FLORIDAN AQUICLUDE
PASCO
HILLSBOROUGH
MANATEE
SARASOTA
CHAR-LOTTE
-100
-50
-10
-150
Mean Sea Level
FLORIDAN AQUIFER
OCALA GROUP
TAMPA FORMATION AND SUWANNEE LIMESTONE
LAKE CITY LIMESTONE
AVON PARK LIMESTONE

Figure 1.16. Generalized Hydrogeologic North-South Section along Line A-A' Shown in Figure 1.13 (modified from Wright 1974)

aquiclude predestines the hydraulic conductivity to be low to very low, particularly in the vertical direction. The dense, waxy or greasy clays, even in thin layers, are essentially impermeable to the flow of ground water under the vertical hydrologic gradients that exist naturally in the Central Florida Phosphate District. In the Hawthorn, Tampa, and Tamiami formations, thick deposits of such dense clays are common and leakance values are generally in the range of 1×10^{-5} to 1×10^{-6} gallons per day per cubic foot; in the less dense or less packed clay layers, such values may be larger by 1 to 3 orders of magnitude.

In the study area, the Floridan aquiclude is present everywhere but not necessarily as a solid mass of impermeable or slightly permeable materials. Thin layers of sandy limestone and sand or shell beds give rise to the minor aquifers previously discussed (Figure 1.11). However, none of these minor aquifers is present as a continuous unit throughout the entire study area, and all are more or less enclosed by clays of the Hawthorn, Tampa, and Tamiami formations, varying from place to place.

2) Floridan Aquifer

a) General Description

The Floridan aquifer is Florida's rainbarrel: it furnishes about 90 percent of the water withdrawn for human use in the Floridan peninsula north of the latitude of Lake Okeechobee (Parker 1975). The aquifer, a huge "layer-cake" of mostly limestone and dolostone faulted and folded in many places, underlies about 82,000 square miles in the southeastern states, extending northward under the southeastern corner of Alabama and beneath the Coastal Plain of Georgia and South Carolina (Figure 1.17) and thinning out to a feather edge near the inner border of the Coastal Plain. Its thickness in Florida ranges from less than 1,000 feet to more than 3,000 feet.

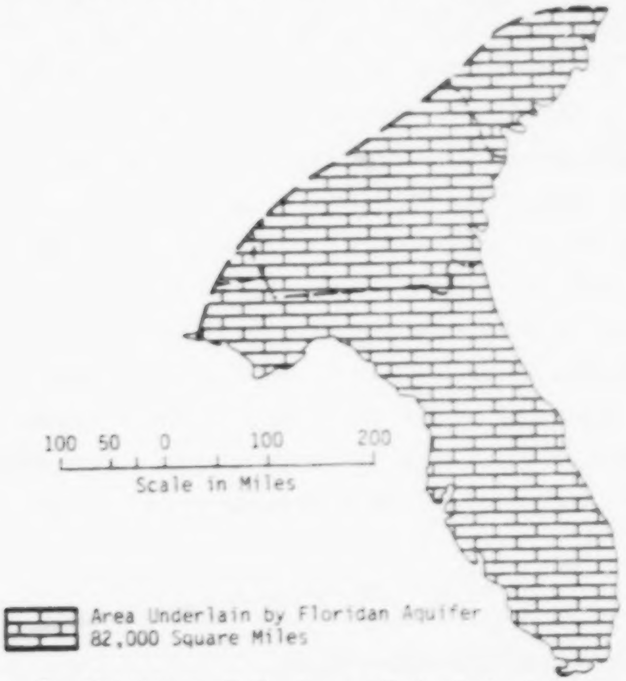


Figure 1.17. Southeastern U.S. Areas Underlain by Floridan Aquifer (prepared by Geraghty & Miller, Inc.)

The altitude of the top of the Floridan aquifer in the study area ranges from land surface (about 100 to 110 feet above mean sea level) in the western part of the Green Swamp in northwestern Polk County to as much as

700 feet below msl in southeastern Charlotte County (Figure 1.14). This represents an altitude loss of approximately 800 feet in 110 miles and is a measure of the constructional dip of the Ocala anticline in this part of the state.

The folding and faulting that produced the present warped surface of anticlines, synclines, large monoclinal surfaces, and numerous faults and fissures created the rock structures that permitted subsequent development of hydraulic head potentials sufficient to produce vigorous circulation of ground water through the openings in the rocks. The faults, joints, bedding planes, and other openings created an open, permeable fabric through which water circulates freely from the higher to the lower areas. The flowing water dissolves the calcareous rocks, enlarging the openings so that water moves through a maze of interconnected passageways in many parts of the aquifer. Large caverns (in some, up to 90 feet from ceiling to floor) are commonly strung out along the linear fissures. These caverns developed because, during times of lowered sea level in the Pleistocene (Ice Age) epoch, the sea level around the Floridan peninsula dropped hundreds of feet lower than it is now and groundwater levels in the aquifer dropped accordingly. Also, sinkholes developed, extending in many places from the land surface to depths related to each lowered groundwater level, and many subsequently became filled with detrital materials, chiefly sand, silt, and clay. Today, these old filled sinkholes usually are the sites of lakes; at many places, they act as funnels to gather and transmit surface water or shallow ground water as direct recharge to the Floridan aquifer. Essentially, the Floridan aquifer behaves as a well-integrated hydrologic unit although, in some places, lenses or local beds of low transmissivity tend to confine water beneath them.

b) Hydrologic Characteristics

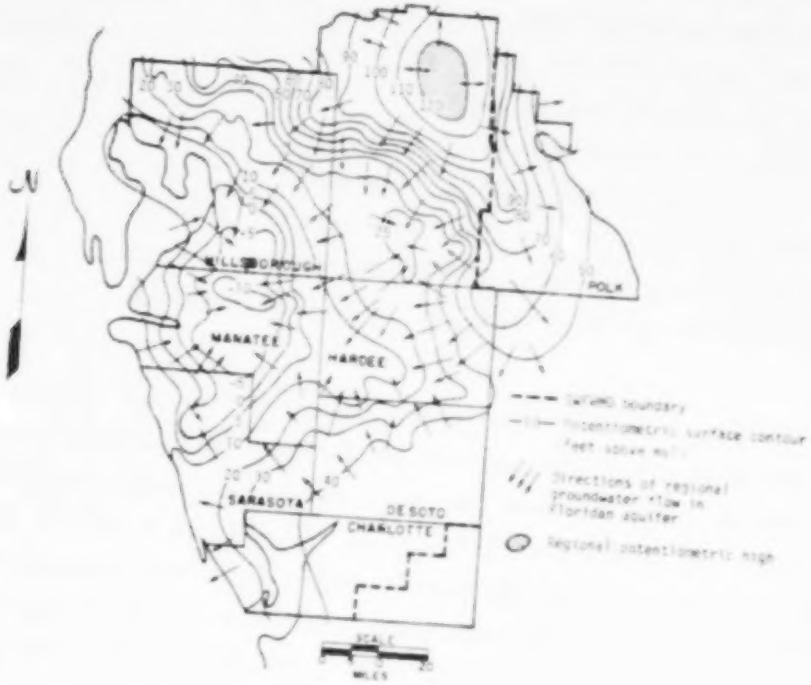
The transmissivity of the Floridan aquifer differs widely from place to place, being very much affected by the presence or absence of solution openings; values range from approximately 2×10^4 to 2×10^6 gallons per day per foot, and storage coefficient values range from approximately 2×10^{-3} to 1.6×10^{-5}. Individual large-diameter public-supply wells tapping high-transmissivity zones commonly yield 5,000 gallons per minute (7.2 million gallons per day), and some (e.g., a 26-inch well in Lakeland with 292 feet of casing and a total depth of 1,200 feet) yield as much as 6,500 gallons per minute (9.36 million gallons per day) with a drawdown of only 11.6 feet (Stewart 1959). Stringfield (1966) reports another high-yield well in Polk County: it is 18 inches in diameter, was cased to 324 feet and drilled to 852 feet, and produces 7,500 gallons per minute (10.8 million gallons per day) with only 9 feet of drawdown.

Generally throughout the study area, the Floridan aquifer's highest yields are from the dolostone unit of the Avon Park limestone. The transmissivity of this cavernous tan-brown dolostone ranges widely from place to place: the USGS reports values of 770,000 and 2,100,000 gallons per day per foot for two Floridan aquifer wells near Fort Lonesome in the southeastern corner of Hillsborough County; and Wilson (1975) reports values in Hardee and DeSoto counties ranging from 1,000,000 to 2,200,000 gallons per day per foot.

Free flows from Floridan aquifer wells and springs may occur wherever the potentiometric surface is above the land surface. From 1961 through 1974, there was little change in the area of flow. In general, the largest changes (a decrease in the area of flow) have been in the upper Peace River valley; in coastal Sarasota, Manatee, and Hillsborough counties; and in southeastern Hillsborough and adjacent parts of Hardee and DeSoto counties. These areas are primarily in the middle and southern half of the Central Florida Phosphate District where the pumping of large quantities of ground water chiefly for agricultural uses (mostly irrigation and food processing) and for phosphate mining and millage has resulted in the large-scale lowering of the potentiometric surface (Figure 1.18).

c) Fluctuations of Potentiometric Surface

The potentiometric surface of an artesian aquifer is the counterpart of the water table of an unconfined aquifer; however, whereas the water table is an air/water contact surface, the potentiometric surface is a



N
HILLSBOROUGH
POLK
MANATEE
HARDEE
SARASOTA
DE SOTO
CHARLOTTE
SWFWMD boundary
Potentiometric surface contour (feet above msl)
Directions of regional groundwater flow in Floridan aquifer
Regional potentiometric high
SCALE
MILES

Figure 1.18. Potentiometric Surface of Floridan Aquifer for May 1975 Showing Green Swamp High and Directions of Regional Artesian Water Flow in Floridan Aquifer (adapted from USGS data)

pressure surface standing above the bottom of the confining bed or beds that lie above and cap the artesian aquifer.

(i) Seasonal and Short-Term Fluctuations

The potentiometric surface is continually fluctuating (Figure 1.19) in response to a variety of forces (earthquakes, winds, tides, trains, and atmospheric pressure changes as well as recharge to and discharge from the aquifer [Parker and Stringfield 1950]) exerted on the artesian system. Figure 1.19 shows seasonal, short-term, and long-term fluctuations as measured in a well in Hardee County 4 miles east of Wauchula and 0.7 mile south of the Old Sebring Road; this is a fairly typical well in the study area and indicates large drawdowns when each irrigation season begins and the almost equally large and rapid recovery that occurs when each irrigation season ends. The data plotted are month-end water levels taken from an automatic

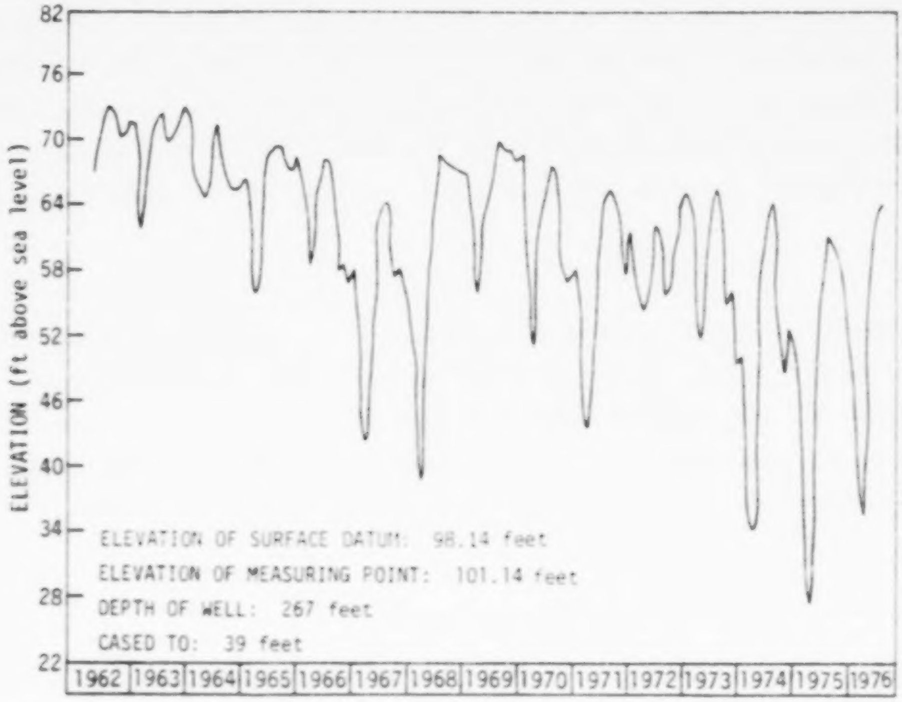


Figure 1.19. Seasonal Fluctuations of Potentiometric Surface in Observation Well Tapping Floridan Aquifer in Central Northern Hardee County, Florida (prepared from USGS data)

water-level recorder operated by the USGS in cooperation with the SWFWMD and the Florida Bureau of Geology. Instantaneous or other short-term fluctuations (e.g., those caused by earthquakes) are not shown in the illustration. The record of this particular well shows seasonal fluctuations due to irrigation that are as great as 42 feet (September 1974 to May 1975). Also, when comparing the early part of the record (1962-73) with the later part (1973-76), there is evidence of an increase in amplitude of drawdown and recovery. This indicates increasing total irrigation pumpage during the period because irrigation pumpage is of a seasonal nature, which is contrary to pumpage for industrial uses.

It is important to note the overall downward trend of water levels and that it is long-term, even though recovery following some irrigation seasons is equal to or greater than the previous drawdown. The decline is about 9 feet in 14 years (1962-76), indicating that more artesian water is being taken from storage than is naturally being replenished by recharge. It is also important to note the abrupt change of the potentiometric surface when the pumping rate is changed. This is characteristic of artesian systems and indicates pressure changes, not the dewatering of the artesian aquifer, that would occur in the water-table aquifer if the water table were to drop.

Where irrigation pumpage is small or only natural conditions prevail in southern Florida, the fluctuation of the potentiometric surface seldom exceeds 10 feet between September and May (high and low) levels (USGS data). One such large area is the Green Swamp where, at its crest, fluctuations generally range between 120 and 130 feet above mean sea level.

(ii) Long-Term Fluctuations

Long-term fluctuations generally reflect either a lengthy decline or rise of the potentiometric surface. In the study area, the long-term fluctuation is downward (Figure 1.19). Figure 1.20 is a map of the decline of the potentiometric surface in the study area determined by comparing potentiometric high-water levels of September 1949 and those of September 1975. The major center of decline is in the phosphate mining area in central southern Polk County where head loss was 30 feet or more between 1949 and 1975. In considering this map, one must realize that the data base was much narrower for the 1949 water levels than for those of 1975. This implies that the map is not very reliable, nor can all of the decline or even most of it be attributed to phosphate operations; agricultural uses extend the area far southward, westward, and eastward.

Figure 1.21 maps the change in potentiometric levels for low-water conditions from May 1969 to May 1975. It is evident that there have been greater declines over a much larger area during low water, which coincides with the irrigation season.

Another way of observing long-range fluctuations over periods of time is to compare potentiometric maps for different years. The contours

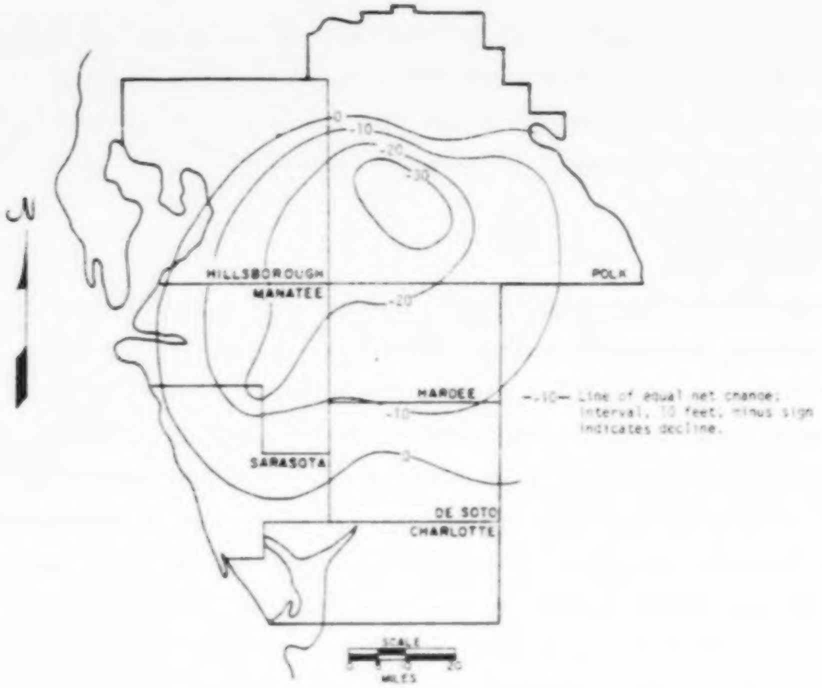
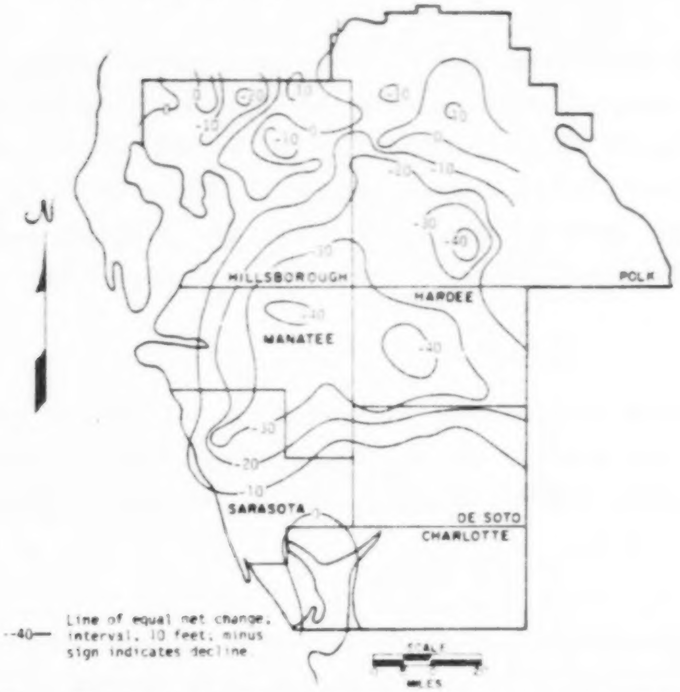

N
-0
-10
-20
-30
HILLSBOROUGH
MANATEE
POLK
-20
HARDEE
-10
SARASOTA
0
DE SOTO
CHARLOTTE
—10— Line of equal net change; interval, 10 feet; minus sign indicates decline.
SCALE
0 10 20
MILES

Figure 1.20. Decline of Potentiometric Surface of Floridan Aquifer between September 1949 and September 1975 (adapted from USGS data)


N
0
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-10
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-30
-40
-30
HILLSBOROUGH
POLK
HARDEE
-40
MANATEE
-40
-30
-20
-10
SARASOTA
0
DE SOTO
CHARLOTTE
—40— Line of equal net change, interval, 10 feet; minus sign indicates decline.
SCALE
0 10 20
MILES

Figure 1.21. Change in Potentiometric Surface of Floridan Aquifer, May 1969 to May 1975 (adapted from USGS data)

reflect the hydrologic regimen of the artesian system, denoting among other things the high areas of recharge and the low areas of discharge, or the points of artificial recharge and large withdrawal of water from wells. Figures 1.22, 1.23, 1.24, and 1.25 show conditions for 1949, 1969, 1975, and 1976 respectively.

Figure 1.22 (September 1949) represents a period before human activities had any noticeable effect on the potentiometric surface. It graphically portrays the equilibrium between input to and outgo from the artesian system responding to long-term natural conditions; in other words, it is a hydrologic benchmark representative of high-water conditions. In the Central Florida Phosphate District, normal highs are in September and October and lows are usually in May; between these two periods, the water levels in artesian wells undergo natural fluctuations ranging from a few centimeters to a meter or so in the Gulf shore area and to about 10 feet in the interior. Thus, when comparing May potentiometric maps with those for September, one should add enough to May levels to compensate for these normal, seasonal fluctuations.

Because low water-level periods place the greatest stress on coastal water-supply systems, most maps have been prepared for May conditions, thus reflecting the worst conditions to be reckoned with by management officials. However, for good water management, there is need to know not only the lowest but also the high water levels when flooding occurs. Thus, in September 1975, the USGS began preparing maps twice a year (May and September).

A quick glance at these maps shows that the altitude of the potentiometric surface at the crest of the Green Swamp High (Figure 1.24) has always contained at least a 120-foot contour and in 1949 had a 130-foot contour.

There is not much difference in the overall pattern presented in Figures 1.22, 1.23, 1.24, and 1.25, but there are local and regional differences chiefly because of (1) dredging of tidal streams for both commercial

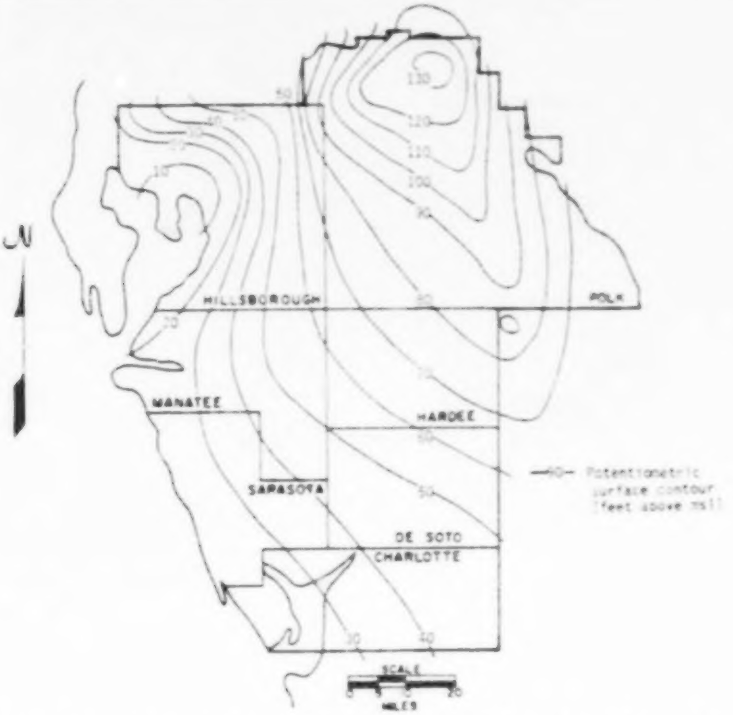
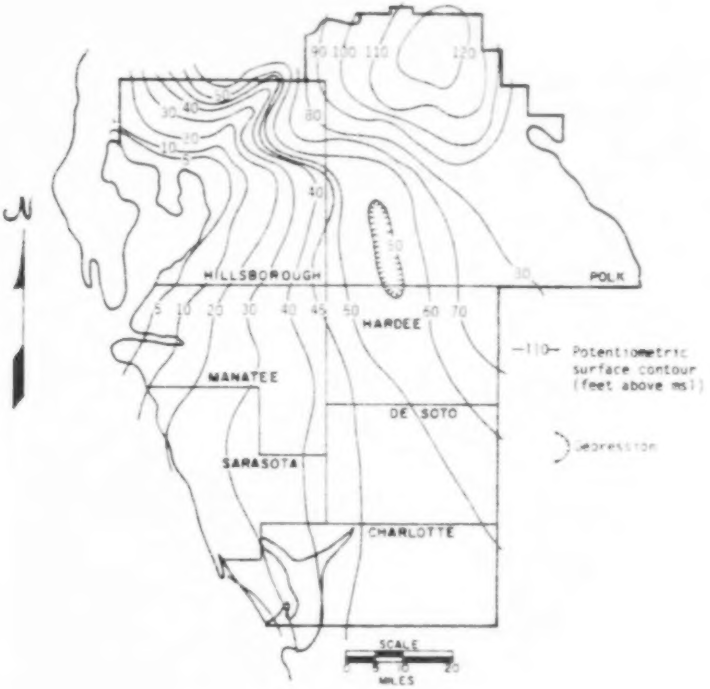

50
130
120
110
100
90
40
30
20
10
HILLSBOROUGH
80
POLK
20
70
MANATEE
HARDEE
60
SARASOTA
50
DE SOTO
CHARLOTTE
30
40
SCALE
0 5 10 20
MILES
—40— Potentiometric surface contour (feet above msl)

Figure 1.22. Potentiometric Surface of Floridan Aquifer, September 1949 (adapted from USGS data)


90 100 110
120
30
40
20
10
5
80
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50
HILLSBOROUGH
30
POLK
5 10 20 30 40 45 50
60 70
HARDEE
MANATEE
DE SOTO
SARASOTA
CHARLOTTE
SCALE
0 5 10 20
MILES
—110— Potentiometric surface contour (feet above msl)
Depression

Figure 1.23. Potentiometric Surface of Floridan Aquifer, May 1969 (adapted from USGS data)

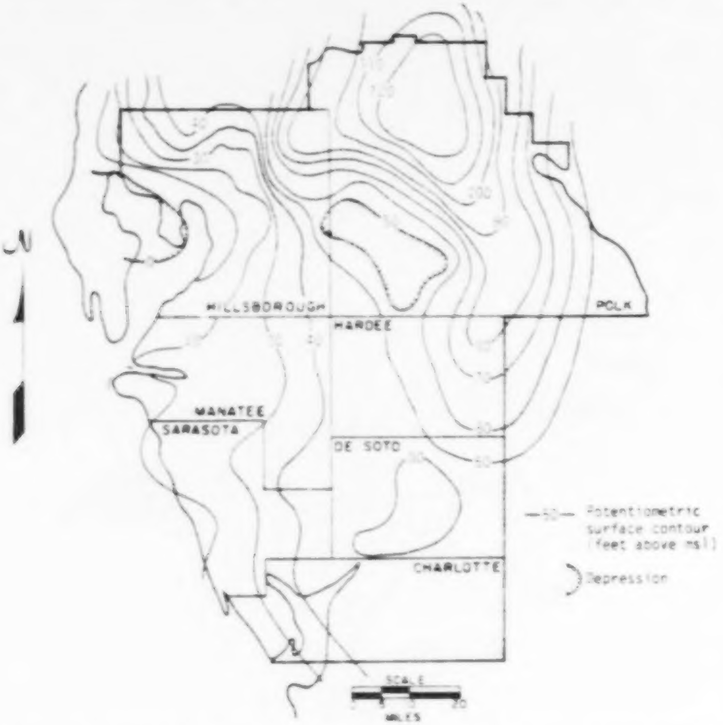
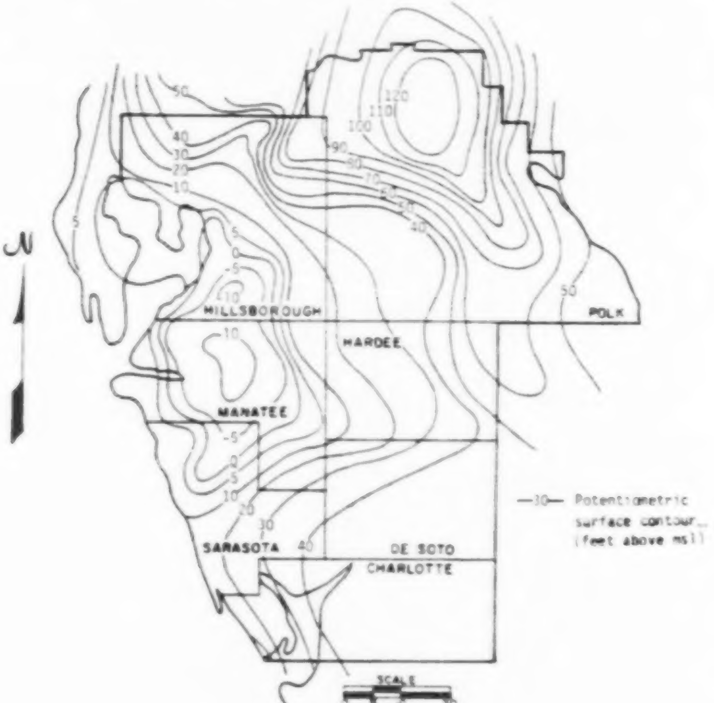

N
HILLSBOROUGH
POLK
HARDEE
MANATEE
SARASOTA
DE SOTO
CHARLOTTE
120
110
100
90
50
40
30
10
—50— Potentiometric surface contour (feet above msl)
Depression
SCALE
0 5 10 20
MILES

Figure 1.24. Potentiometric Surface of Floridan Aquifer, September 1975 (adapted from USGS data)


N
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HILLSBOROUGH
POLK
HARDEE
MANATEE
SARASOTA
DE SOTO
CHARLOTTE
-10
-5
0
5
10
20
30
40
—30— Potentiometric surface contour (feet above msl)
SCALE
0 5 10 20
MILES

Figure 1.25. Potentiometric Surface of Floridan Aquifer, May 1976 (adapted from USGS data)

and pleasure-boat navigation; (2) drainage ditching of the coastal wetlands for mosquito control; (3) development of large municipal water-supply well fields in the coastal area and some large self-supplied industrial wells in the larger municipal areas; (4) growth of the phosphate mining and milling industry, primarily in the upper half of the Central Florida Phosphate District; (5) growth of agribusiness in the same area at about the same time (beginning about 1964 on a large scale); and (6) large-scale development of agribusiness beginning about 1973 and centering in Manatee County but extending northward into Hillsborough, southward into Sarasota, and southeasterly into Hardee and DeSoto counties.

The coastal dredging and ditching not only lowered water levels but carried seawater inland for several miles in most of the dredged channels, thus introducing salt water into previous freshwater areas and inducing saltwater encroachment, resulting at least partly in the loss of coastal well fields for such cities as Sarasota, St. Petersburg, Tampa and, recently, New Port Richey. The loss of these well fields and the growth of population along the coast caused the cities and Pinellas County (outside the study area) to go as much as 40 miles inland for their new freshwater supplies and to engage in bitter quarrels over new water supplies and protection of the remaining coastal freshwater sources. The squabble is still going on in the Tampa Bay area - and to the south, Sarasota is contesting the southward movement of the phosphate industry as the ore deposits are being mined to exhaustion in the northern part of the Central Florida Phosphate District.

In reference to the issue of long-term trends with respect to the potentiometric surface of the Floridan aquifer, the following main changes can be seen:

- A large area of internal flow (cone of depression) showed up in 1969 in the phosphate mining area (Figure 1.23).

- The 20-foot contour that extended seaward from the lower Tampa Bay area in 1949 had moved inland more than 11 miles by 1969 (Figure 1.23), and in another 7 years (May 1976, Figure 1.25) this same contour had continued its inland movement and had occupied a site some 48 miles southeastward on the Hardee-DeSoto line. Also, a sizable cone of depression centered in Manatee County but extending northwest to Pinellas County, north to Tampa, and south almost to Sarasota, with its deeper parts more than 10 feet below mean sea level, developed in an area in which there is no phosphate mining but large-scale agricultural pumping that begins each year in December or January and continues through the following May into June.

d) Saltwater Encroachment

Along the coast of the Central Florida Phosphate District, the outflow of fresh ground water from the Floridan aquifer has long been in equilibrium with the denser saline water of the Gulf, thereby preventing inland saltwater encroachment. However, if the coastal freshwater head were to be reduced sufficiently, the outflow of ground water would be reduced and the saltwater/freshwater interface would gradually move inland, causing seawater to replace the fresh. Thus, the decline in the potentiometric surface of the Floridan aquifer has caused great concern. There have been localized cases in which wells have shown increases in their chloride content, and several studies are in progress (although specific data are not yet available).

The whole issue of saltwater encroachment is very complex (Parker 1955, Reichenbaugh 1972). In certain parts of Manatee County, for example, the potentiometric surface has declined below mean sea level generally in the spring and then has risen above msl again during the rainy season; while some bay people suspect that substantial saltwater encroachment should have occurred, current data do not support this suspicion. However, there is a great lag in the response of seawater to inland movement as a result of lowered freshwater levels inland. Perhaps not enough time has elapsed since the drawdowns occurred on a scale large enough to induce saltwater encroachment very far inland, and the lowering during the irrigation season may very well be offset by the rise during off-irrigation. Although highly speculative, it is also possible that geologic structure plays a role in retarding or preventing saltwater encroachment.

A much greater threat to the quality of the freshwater resources in the coastal zones of the Floridan aquifer is the contamination of the freshwater zones by highly mineralized water (predominantly water with a high sulfate content) leaking upward from deeper, more mineralized zones (Figure 1.26) through uncased or leaky well casings. This problem has been recognized by SWFWMD which, since 1975, has been plugging as many of these free-flowing artesian wells as funding permits. This program has two goals: by plugging the wells, water loss is prevented, thereby increasing aquifer pressures and in turn helping to prevent saltwater encroachment; and the contamination by upward leakage is prevented.

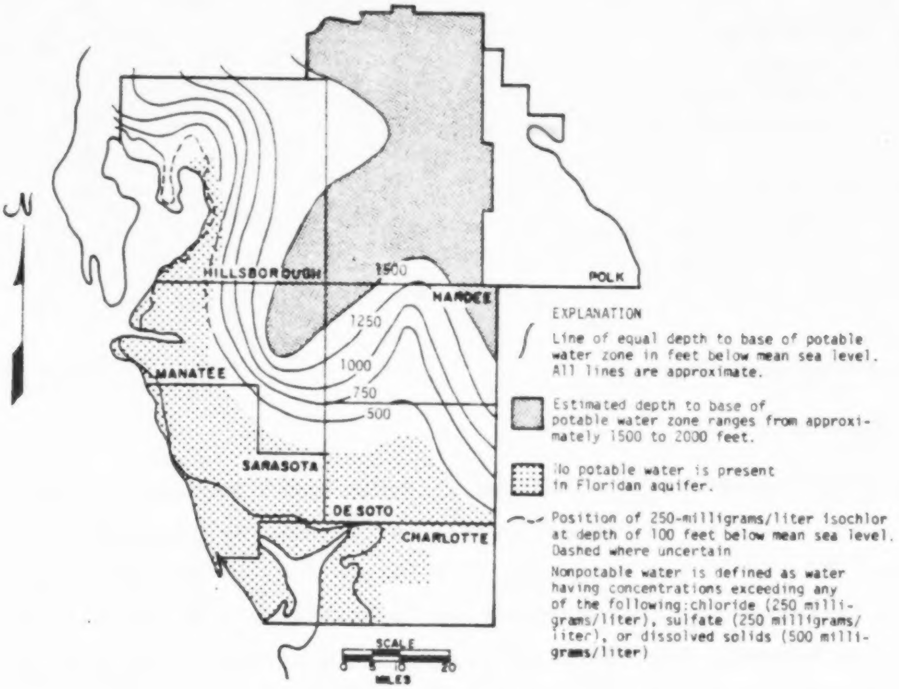
N
HILLSBOROUGH
POLK
HARDEE
1500
1250
1000
750
500
MANATEE
SARASOTA
DE SOTO
CHARLOTTE
SCALE
0 5 10 20
MILES
EXPLANATION
Line of equal depth to base of potable water zone in feet below mean sea level. All lines are approximate.
Estimated depth to base of potable water zone ranges from approximately 1500 to 2000 feet.
No potable water is present in Floridan aquifer.
Position of 250-milligrams/liter isochlor at depth of 100 feet below mean sea level. Dashed where uncertain
Nonpotable water is defined as water having concentrations exceeding any of the following: chloride (250 milligrams/liter), sulfate (250 milligrams/liter), or dissolved solids (500 milligrams/liter)

Figure 1.26. Depth to Base of Potable Water Zone in Floridan Aquifer, 1975 (U.S. Army Corps of Engineers 1977)

C. PRESENT WATER DEMANDS IN STUDY AREA

1. Introduction

This subsection presents the study area's existing water demands (1976).* Based on existing data, the results appear in Table 1.16 (for an explanation, see subsection C.3). The Four River Basins study (U.S. Army Corps of Engineers 1977), SWFWMD's (1977) water-use plan, and personal interviews were the information sources for water-demand estimates in the study area. Consumption categories found to be representative of demands in the study area were as follows:

- Municipal
- Industrial
  - Phosphate industry (mining and beneficiation; chemical processing plants)
  - Citrus processing
  - "Other" industry
- Agricultural
  - Citrus
  - Truck crops
  - Irrigated pasture
- Miscellaneous
  - Power production
  - Golf courses

2. Historical Water Demands

a. Municipal

Municipal groundwater withdrawals in the seven counties of the study area in 1975 totaled 95.8 million gallons per day, an increase of 49 percent since 1965 and 26 percent since 1970 (Table 1.17). The most withdrawal was in Hillsborough and Polk counties (approximately 86 percent of the municipal withdrawals for the study area). Much of the withdrawal in Hillsborough County was in the northwest portion where several large well fields supply water for St. Petersburg and for Pinellas County. Decreases

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*It should be noted that water demands are continuously updated by USGS and SWFWMD.

Table 1.16. Water Demands for Study Area by Use and County in 1976

County	Industry					Agricultural*			Miscellaneous*		
		Phosphate†									
	Public†	Mines	Plants	Citrus Processing**	Other Industries**	Citrus Irrigation	Truck-Crop Irrigation	Irrigation Pasture	Power Plants	Golf Courses	Total
Charlotte											
Ground water	4.62	–	–	–	0.29	9.09	3.21	5.46	–	0.05	23.51
Surface water	2.24	–	–	–	–	–	–	–	–	–	2.24
DeSoto											
Ground water	2.58	–	–	0.20	0.11	62.79	3.46	39.82	–	0.05	109.01
Surface water	–	–	–	–	–	–	–	–	–	–	–
Hardee											
Ground water	2.61	–	–	0.31	0.22	69.58	6.29	111.13	0.23	0.05	190.42
Surface water	–	–	–	–	–	–	–	–	–	–	–
Hillsborough											
Ground water	15.33	7.27	7.19	0.10	14.25	38.48	17.24	4.96	–	0.32	105.34
Surface water	72.36	–	12.10	–	–	–	–	–	–	–	84.16
Saline water	–	–	–	–	–	–	–	–	2,236.84	–	2,236.84
Manatee											
Ground water	–	–	5.80	0.51	2.79	20.03	14.15	24.88	15.0	0.50	83.66
Surface water	28.50	–	–	–	–	–	–	–	–	–	28.50
Polk											
Ground water	43.43	159.00	81.50	18.35	4.51	140.79	1.36	1.02	28.15	1.60	485.21
Surface water	–	–	–	–	–	–	–	–	254.79	–	254.78
Sarasota											
Ground water	27.14	–	–	–	1.54	2.34	5.69	21.29	–	1.20	54.40
Surface water	1.10	–	–	–	–	–	–	–	–	–	1.10
Total											
Ground water	95.71	166.27	94.49	20.07	23.70	343.40	51.90	208.56	43.38	3.77	1,051.85
Surface water	104.20	–	12.10	–	–	–	–	–	254.78	–	371.08
Saline water	–	–	–	–	–	–	–	–	2,236.84	–	2,236.84

*U.S. Army Corps of Engineers (1977).
**SWFWMD (1977).
†USEPA (1977a).

Table 1.17. Municipal Groundwater Withdrawals by County during 1965, 1970, and 1975

County	Million Gallons per Day		
	1965*	1970**	1975***
Charlotte	1.0	0.4	0.3†
DeSoto	1.0	0.5	0.8
Hardee	1.0	0.7	0.9
Hillsborough	29.0	35.2	48.1
Manatee	4.0	0.3	0.0
Polk	22.0	27.7	34.2†
Sarasota	6.3	11.0	11.5
Total	64.3	75.8	95.8

* Estimated (Pride, 1965).
** Estimated (Pride, 1970).
*** U.S. Army Corps of Engineers (1977).
† Source data adjusted to include whole county.

in Charlotte and Manatee counties were attributed to the increased dependence on surface water.

b. Self-Supplied Industrial

Self-supplied industrial groundwater withdrawals totaled 285.8 million gallons per day in 1975, a decrease of approximately 15 percent since 1965 and 0.6 percent since 1970 (Table 1.18). The most withdrawal was in Polk County, with a large percentage being for phosphate mining and processing and related industries as well as food processing, particularly citrus. The other counties accounted for very small withdrawals, the exception being Hillsborough, which withdrew 15.0 million gallons per day in 1975. Hillsborough's decrease from 80 million gallons per day in 1965 to 15.0 million gallons per day in 1975 was attributed to a decrease in mining activities over the 10-year period as well as an increase by industrial facilities using hookups to municipal water-supply distribution systems.

Table 1.18. Self-Supplied Industrial Fresh Groundwater Withdrawals by County in 1965, 1970, and 1975

County	Million Gallons per Day 1965*	1970**	1975***
Charlotte	0.0	0.1	0.3
DeSoto	2.1	0.7	0.3
Hardee	0.8	0.1	1.1
Hillsborough	80.0	40.0	15.0
Manatee	1.3	3.0	3.2
Polk	250.0	236.0	264.4
Sarasota	0.9	7.6	1.5
Total	335.1	287.5	285.8

* Estimated (Pride, 1965).
** Estimated (Pride, 1970).
*** SWFWMD (1977).

c. Agricultural

Total estimated (not actual measured) agricultural groundwater withdrawals in the study area during 1975 (Table 1.19) was 754.9 million gallons per day, an increase of approximately 48 percent since 1965 and 66 percent since 1970. The most withdrawal (264.7 million gallons per day) was in Polk County in 1975, a decrease of approximately 9 percent since 1965; probably, this reduction was largely the result of a decrease in irrigated acreages as large-scale urban developments replaced citrus acreage in that county and irrigation practices became more efficient and crop patterns changed.

Table 1.19. Agricultural Groundwater Withdrawals by County in 1965, 1970, and 1975

County	Million Gallons per Day 1965*	 1970**	 1975***
Charlotte	5.5	28.2	28.0[†]
DeSoto	19.0	64.7	103.4
Hardee	38.0	62.5	186.3
Hillsborough	40.0	64.2	73.3
Manatee	82.0	49.5	65.5
Polk	290.0	156.1	264.7[†]
Sarasota	34.0	27.3	33.7
Total	508.5	452.5	754.9

* Pride (1965).
** Pride (1970).
*** U.S. Army Corps of Engineers (1977).
[†] Source data adjusted to include whole county.

Based on the available data, groundwater withdrawals for agricultural purposes (excluding canning, preserving, and other industrial uses of water for processing agricultural products) generally showed a marked increase during the three time intervals that were compared (Table 1.20).

Table 1.20. Quantitative Changes in Agricultural Groundwater Withdrawals by County from 1965 to 1970, 1970 to 1975, and 1965 to 1975

	Million Gallons per Day*		
County	1965 to 1970	1970 to 1975	1965 to 1975
Charlotte	22.7	- 0.2	22.5
DeSoto	45.7	38.7	84.4
Hardee	24.5	123.8	148.3
Hillsborough	24.2	9.1	33.3
Manatee	- 32.5	16.0	- 16.5
Polk	-133.9	108.6	- 25.3
Sarasota	- 6.7	6.4	- 0.3
Total	- 56.0	302.4	+246.4

* A positive sign indicates an increase in withdrawals for the given time frame; a negative, a decrease in withdrawals.

During 1965-70, only Manatee and Polk exhibited reduced groundwater withdrawals; the other five counties showed increases. During 1970-75, records for all counties except Hardee and Polk showed moderate to small increases. In the 10-year interval (1965-75), the counties exhibiting overall decreases in groundwater agricultural pumpage were Polk, Manatee, and Sarasota. Hardee and DeSoto had the largest apparent gains, while Hillsborough and Charlotte showed moderate increases.

Again, it is necessary to reiterate that the basic agricultural pumpages for each county are estimated, not measured, and that they are therefore subject to large errors. However, the general trend toward an increase appears valid. In looking at the changes in potentiometric maps for this entire period, one is struck by the growth and development of a huge cone of depression in the potentiometric surface centering in Manatee County (Figure 1.24), which bespeaks of increasing, not decreasing, pumpage. This great area of drawdown, first mapped by the USGS in May 1971, appeared as a wide and deep trough running from southwestern Hillsborough County diagonally to the southeast across Manatee and Hardee counties and spreading into northern DeSoto County; it retained its trough-like shape until May 1975 when it became an irregular, elliptical area of internal flow bounded by a closed potentiometric contour at +5 feet mean sea level and containing pockets of drawdown at -10 feet msl in its central area (Figure 1.25). Since 1975, this great cone of depression induced principally by agricultural pumpage has centered in Manatee County during the irrigation seasons and tends to retain its irregular elliptical shape with an approximate 50-mile long axis almost due north-south roughly parallel to the Gulf shoreline and a 30-mile long east-west axis through Bradenton. There can be no doubt that the increasing agricultural pumpage within the area is mainly responsible for this large cone of depression. With the cessation of irrigation pumpage in the fall, this extensive cone of depression tends to disappear. Water in the area, however, has never regained its original levels before pre-large-scale irrigation development.

d. Changes in Groundwater Use

Table 1.21 indicates that the total estimated groundwater withdrawal in the Central Florida Phosphate District was 92.1 million gallons per day less in 1970 than in 1965 and 228.6 million gallons per day more in 1975 than in 1965. It is believed, however, that the 1965 pumpage did not exceed the 1970 and that there are errors in either the 1965 or 1970 data or both. The fact that most of the data are not based on measured values lies at the basis of this uncertainty, and this is particularly a problem with irrigation because irrigation pumpage is "reconstructed" using the irrigated acreage and a standard crop-irrigation water-application rate. The estimates are naturally less than actual pumpage, which includes tail-water volumes.

Table 1.22 shows changes in groundwater withdrawals by major categories of use from 1965 to 1970, 1970 to 1975, and 1965 to 1975. The greatest change over the 10-year period occurred between 1970 and 1975 as the population was experiencing its greatest growth and irrgation was having its largest expansion.

Table 1.21. Total Groundwater Withdrawals by County in 1965, 1970, and 1975

County	Million Gallons per Day 1965	 1970	 1975
Charlotte	6.5	28.7	28.6
DeSoto	22.1	65.9	104.5
Hardee	39.8	63.3	188.3
Hillsborough	149.0	139.4	136.4
Manatee	87.3	52.8	68.7
Polk	562.0	419.8	563.3
Sarasota	41.2	45.9	46.7
Total	907.9	815.8	1,136.5

Table 1.22. Changes in Groundwater Withdrawals by Major Categories of Use from 1965 to 1970, 1970 to 1975, and 1965 to 1975

Use	Million Gallons per Day* 1965 to 1970	 1970 to 1975	 1965 to 1975
Municipal	+11.5	- 1.7	- 49.3
Industrial	-47.6	+ 20.0	+ 31.5
Agricultural	-56.0	+302.4	+246.4
Total	-92.1	+320.7	+228.6

* A positive sign indicates an increase in withdrawals for the given time frame; a negative, a decrease in withdrawals.

3. General Water Demands

a. Municipal

Table 1.23 is an EPA inventory of consumers of more than 100,000 gallons per day of potable water (both surface and ground) in the 7-county study area. In Table 1.24 which summarizes this information, the estimated average daily withdrawal from surface-water sources in the study area is seen to be 81.137 million gallons per day and the total estimated average daily withdrawal from groundwater sources to be 80.754 million gallons per day. In checking these data for validity against SWFWMD's 1977 estimates, the EPA inventory was noted to be higher for all counties. An additional check using the per-capita consumption rate of 136 gallons (SWFMWD 1977) and the University of Florida's 208 population projections (see Volume III of this series of working papers) again revealed that the EPA inventory was higher except for DeSoto, Hardee, and Hillsborough counties. The three counties were therefore adjusted using the per-capita consumption rate just noted.

Peak consumption throughout the study area could not be determined from the EPA inventory. The Four River Basins study, however, reveals that the monthly municipal water-consumption peak demands occur in April and the minimum in September and February.

b. Industrial

1) Phosphate Industry

Data on water used by individual phosphate mines and plants were provided by the Florida Phosphate Council but are confidential. Thus, only the total water demands by county are presented (Table 1.16).

Although the actual quantity varies greatly, approximately 10,000 gallons of water are necessary to produce 1 ton of approximately 70 percent Bone Phosphate of Lime (BPL) rock. However, not all of this water is consumptively used; from the data provided by the Florida Phosphate Council it was determined that an average of 1,500 gallons of water is required to

Table 1.23. Inventory of Public Water Supplies

	Name	City	County	Avg Daily Consumption (mgd)*
Surface Water	Punta Gorda Water Department (Shell and Prairie Creek)	Punta Gorda	Charlotte	1.60
	General Development Utilities Inc. (Big Slough canal)	Port Charlotte	Charlotte	2.54
	Tampa Water Department (Tampa Reservoir - Hillsborough River)	Tampa	Hillsborough	49.00
	Manatee County Utilities System (Lake Manatee)	Bradenton	Manatee	15.00
	Bradenton Water Department (Braden River)	Bradenton	Manatee	1.80
	General Development Utilities Inc. (Big Slough canal)	Port Charlotte	Sarasota	0.72
Ground Water	General Development Utilities Inc.	Miami	Charlotte	2.22
	General Development Utilities Inc.	Port Charlotte	Charlotte	2.15
	Rotonda West Utility Corp.	Rotonda West	Charlotte	0.25
	Arcadia Water Department	Arcadia	DeSoto	0.40
	G. Pierce Wood Memorial Hospital	Arcadia	DeSoto	0.15
	DeSoto Correctional Institution	Arcadia	DeSoto	0.12
	Wauchula Water Department	Wauchula	Hardee	0.74
	Bowling Green Water Department	Bowling Green	Hardee	0.20
	Plant City Water Department	Plant City	Hillsborough	2.26
	Hillsborough County Utilities	Tampa	Hillsborough	2.20
	Brandon Water Company	Brandon	Hillsborough	2.00
	Temple Terrace Utilities	Temple Terrace	Hillsborough	1.28
	Tampa Suburban Utilities	Tampa	Hillsborough	0.80
	Hillsborough County Utilities (Riveroaks)	Tampa	Hillsborough	0.37
	East Side Water Company	Tampa	Hillsborough	0.31
	Big Bend Utility Company	Apollo Beach	Hillsborough	0.29
	Southeastern Utility	Tampa	Hillsborough	0.20
	Haspallan Water System Inc.	Tampa	Hillsborough	0.12
	Hillsborough Utilities Corp.	Tampa	Hillsborough	0.10
	Lakeland Department of Electricity	Lakeland	Polk	16.72
	Fort Meade Water Department	Fort Meade	Polk	10.00
	Winter Haven Water Department	Winter Haven	Polk	5.00
	Bartow Water Department	Bartow	Polk	2.40
	Department of Water & Pollution Control	Haines City	Polk	1.70
	Auburndale Water Treatment Plant	Auburndale	Polk	1.40
	Garden Grove Water Co.	Winter Haven	Polk	1.00
	Lake Alfred Water Department	Lake Alfred	Polk	0.60
	Garden Grove Water Co. Inc.	Winter Haven	Polk	0.56
	Bartow Air Base	Bartow	Polk	0.52
	Imperial Lakes	Bartow	Polk	0.50
	Frostproof Water Department	Frostproof	Polk	0.35
	Mulberry Water Department	Mulberry	Polk	0.30
	Sun Ray Homes Water Department	Frostproof	Polk	0.25
	Eaton Park	Bartow	Polk	0.21
	City of Wahneta	Wahneta	Polk	0.20
	City of Lake Hamilton	Lake Hamilton	Polk	0.14
	City of Dundee	Dundee	Polk	0.19
	Grenelefe S/D	Haines City	Polk	0.18
	Piper Aircraft	Lakeland	Polk	0.17
	Jan Phyl Utility Co.	Winter Haven	Polk	0.16
	City of Waverly	Waverly	Polk	0.15
	Lake Wales Utility Co.	Malcrest	Polk	0.15
	Babson Park	Bartow	Polk	0.14
	Polk City	Lakeland	Polk	0.14
	Highland City	Lakeland	Polk	0.11
	Crooked Lake Park Water Co.	Lake Wales	Polk	0.10
	Sarasota County Special Utility District #1	Sarasota	Sarasota	9.00
	City of Sarasota	Sarasota	Sarasota	7.00
	Siesta Key Utilities Authority	Sarasota	Sarasota	1.30
	General Development	Port Charlotte	Sarasota	1.10
	Venice Water Department	Venice	Sarasota	1.00
	Englewood Water District	Englewood	Sarasota	0.64
	Venice Gardens Utility Corp.	Venice	Sarasota	0.50
	Florida Cities Water Co.	Sarasota	Sarasota	0.45
	Sorrento Utilities	Nokomis	Sarasota	0.15

*Rounded

Table 1.24. Summary of 1976 Municipal Water Demand

County	Surface Water (mgd)	Ground Water (mgd)
Charlotte	2.237	4.620
DeSoto	–	0.673
Hardee	–	0.941
Hillsborough	49.000	9.955
Manatee	28.800	–
Polk	–	43.429
Sarasota	1.100	21.135
Total	81.137	80.753

produce 1 ton of marketable rock. This means that nearly 85 percent of all water required at the mines and beneficiation plants is recycled water. The SWFWMD (1977) indicates that the industry, which required approximately 317 million gallons per day in 1970, decreased its demand to approximately 243 million gallons per day in 1975 - and much of this decline was possible because of the extensive recycling of process water.

2) Citrus Processing

Florida's citrus processing industry provides 95 percent of the nation's orange juice and is a large user of water (Table 1.16). The data source was SWFWMD's water-use plan (1977). In addition, the Four River Basins study (U.S. Army Corps of Engineers 1977) indicates that the average unit consumption for the citrus processing industry is about 80 gallons per box but that this can vary between 30 and 130 gallons per box.

3) "Other" Industrial Water Demand

This industrial category includes all industry in the study area except phosphate and citrus processing. The data were obtained from SWFWMD

(1977), but the Four River Basins study indicates that water demand data for this category are, at best, scarce.

c. Agricultural

Agricultural withdrawal (Table 1.16) is classified into citrus irrigation, truck crop irrigation, and pasture irrigation. Of all the water users in the study area, agriculture is most directly linked to seasonal and yearly weather fluctuations: actual withdrawal during the dry season or spring production is large; during the rainy season, there is very little if any irrigation. Also, agricultural water use is the least accurately measured (SWFWMD 1977). There are only a few cases in which water is metered and recorded. For this report, estimates were based on the Four River Basins study (U.S. Army Corps of Engineers 1977).

d. Miscellaneous

1) Power Production

Locations of power plants in the study area are indicated in Figure 1.27. The 1976 water requirements for the power industry (Table 1.16) were obtained by direct communication with representatives of Florida Power and Light, Tampa Electric Company, and the City of Lakeland Power Plant (and from the Four River Basins study for Wauchula's power plant). All of the power plants except Florida Power and Light's DeSoto plant (discussed under future water demands) presently generate electricity.

2) Golf Courses

Figure 1.28 shows the general locations of golf courses in the study area. Water demands for golf courses (Table 1.16) were based on the Four River Basins study. The study assumed about 0.4 million gallons per year per acre, a quantity that has historically represented golf-course water use in Florida. The study also assumed that the variation of water used in golf-course sprinkling is 50 percent of the maximum during March,

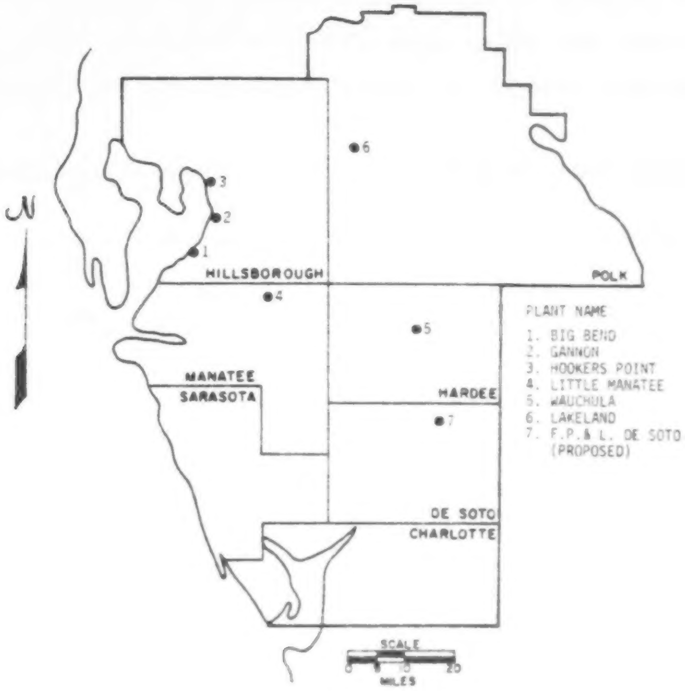
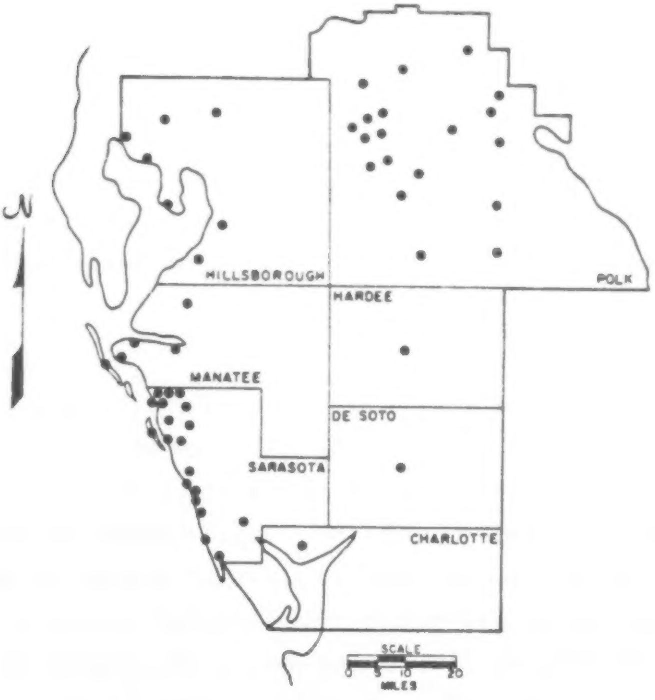

N
3
2
1
6
4
5
7
HILLSBOROUGH
POLK
MANATEE
SARASOTA
HARDEE
DE SOTO
CHARLOTTE
PLANT NAME
1. BIG BEND
2. GANNON
3. HOOKERS POINT
4. LITTLE MANATEE
5. WAUCHULA
6. LAKELAND
7. F.P.& L. DE SOTO (PROPOSED)
SCALE
0 5 10 20
MILES

Figure 1.27. Electric Generating Facilities
(U.S. Army Corps of Engineers 1977)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POLK
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DE SOTO
SARASOTA
CHARLOTTE
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Figure 1.28. Golf Course Locations in Study Area
(U.S. Army Corps of Engineers 1977)

April, and May and 25 percent of the maximum during June-November. In Table 1.25, it can be seen that the three counties in the study area with the greatest water use on golf courses are Polk, Sarasota, and Hillsborough.

Table 1.25. Average Water Demand for Golf Courses by County in 1976*

County	No. of Courses	No. of Holes	Total Acres	Water Use (mgd)
Charlotte	1	18	103	0.1
DeSoto	1	18	125	0.1
Hardee	1	9	100	0.1
Hillsborough	9	135	850	0.9
Manatee	6	126	731	0.8
Polk	16	251	2,362	3.2
Sarasota	21	384	2,270	2.5

Variation	March-May	50%
	June-August	25%
	September-November	25%

*USDA (1960); U.S. Army Corps of Engineers (1976).

4. Summary

As revealed in Table 1.16, the total existing (1976) water demand for the study area averages about 1,423 million gallons per day. This includes only fresh water and does not consider the saline water used for power-plant cooling.

The municipal classification accounts for 191 million gallons per day, or approximately 13 percent of the study area's total. The highest municipal demands are in Hillsborough and Polk counties, while the lowest are in Charlotte, DeSoto, and Hardee counties. Total industrial demand is approximately 317 million gallons per day, or about 22 percent of the study area's total. The major industrial user is the phosphate industry, accounting for approximately 273 million gallons per day, or 86 percent of the total industrial demand. Citrus processing uses 20 million gallons per day, and "other" industries use 24 million gallons per day.

The largest user in the 7-county study area is agriculture, accounting for approximately 610 million gallons per day, or 43 percent of the study area's total. Citrus irrigation uses 344 million gallons per day, or 56 percent of the total agricultural demand.

Of the miscellaneous users in the study area, the various power plants use approximately 301 million gallons per day and golf courses require an average of 4 million gallons per day.

D. FUTURE WATER DEMANDS IN STUDY AREA

The same consumption categories presented in subsection C were used to project water demands for 1985 and 2000. The methodologies differed for each category, however, and are discussed in the following paragraphs.

1. Municipal

Municipal water demands for 1985 (Table 1.26) and 2000 (Table 1.27) were estimated using SWFWMD's per-capita consumption rates of 145 gallons (1985) and 160 gallons (2000) and applying these against the University of Florida's "208" population projections (see Volume III of this series of working papers). As was noted in subsection C, water-demand estimates based on per-capita consumption are rather conservative but provide the best approximation relative to existing data.

2. Industrial

a. Phosphate Industry

The basic data were provided by the Florida Phosphate Council through the EPA, and the first step in reducing the data was to project the life expectancy of not only the existing mines but those for which DRI (Development of Regional Impact) applications are pending and those that are

Table 1.26. Water Demands for Study Area by County in 1985

County	Public†	Industry				Agricultural*			Miscellaneous*		Total
		Phosphate**		Citrus Processing†	"Other" Industries†	Citrus Irrigation	Truck-Crop Irrigation	Irrigation Pasture	Power Plants	Golf Courses	
		Mines	Plants								
Charlotte											
Ground water	6.92	–	–	–	0.35	11.29	2.91	6.04	–	0.13	27.64
Surface water	3.36	–	–	–	–	–	–	–	–	–	3.36
DeSoto											
Ground water	3.77	–	–	0.20	0.27	91.80	2.74	44.07	–	0.13	142.98
Surface water	–	–	–	–	–	–	–	–	172.80	–	172.80
Hardee											
Ground water	3.67	17.34	–	1.00	0.45	81.00	5.10	123.00	0.23	0.05	231.84
Surface water	–	–	–	–	–	–	–	–	–	–	–
Hillsborough											
Ground water	19.55	23.78	7.19	0.08	17.03	34.40	15.70	5.50	–	0.90	124.13
Surface water	111.41	–	12.10	–	–	–	–	–	–	–	123.51
Saline water	–	–	–	–	–	–	–	–	2,236.84	–	2,236.84
Manatee											
Ground water	–	23.00	5.80	0.57	3.60	22.70	12.90	27.50	30.00	0.60	126.87
Surface water	39.30	–	–	–	–	–	–	–	–	–	39.30
Polk											
Ground water	52.24	146.67	81.50	21.50	5.50	139.00	6.70	1.12	28.15	1.80	484.18
Surface water	–	–	–	–	–	–	–	–	254.78	–	254.78
Sarasota											
Ground water	32.90	–	–	–	2.20	2.20	6.30	23.50	–	1.44	68.54
Surface water	1.71	–	–	–	–	–	–	–	–	–	1.71
Total											
Ground water	119.06	210.79	94.49	23.36	29.40	382.39	52.35	230.73	58.38	5.06	1,206.18
Surface water	155.78	–	12.10	–	–	–	–	–	427.58	–	595.46
Saline water	–	–	–	–	–	–	–	–	2,236.84	–	2,236.84

*U.S. Army Corps of Engineers (1977).
**USEPA (1977a).
†SWFWMD (1977).

Table 1.27. Water Demands for Study Area by County in 2000

County	Public†	Industry				Agricultural*			Miscellaneous*		Total
		Phosphate**		Citrus Processing†	"Other" Industries†	Citrus Irrigation	Truck-Crop Irrigation	Irrigation Pasture	Power Plants	Golf Courses	
		Mines	Plants								
Charlotte											
Ground water	12.86	–	–	–	0.38	11.20	3.09	8.86	–	0.20	36.59
Surface water	6.20	–	–	–	–	–	–	–	–	–	6.20
DeSoto											
Ground water	5.75	9.45	–	0.20	0.33	109.56	2.91	64.45	–	0.18	192.83
Surface water	–	–	–	–	–	–	–	–	172.80	–	172.80
Hardee											
Ground water	5.68	63.52	–	1.11	0.69	95.70	5.37	177.00	0.23	0.07	349.37
Surface water	–	2.10	–	–	–	–	–	–	–	–	2.10
Hillsborough											
Ground water	25.51	24.62	7.19	0.09	17.86	31.82	16.63	8.38	–	1.12	133.22
Surface water	122.45	–	12.10	–	–	–	–	–	–	–	134.55
Saline water	–	–	–	–	–	–	–	–	2,236.84	–	2,236.84
Manatee											
Ground water	–	44.79	5.80	0.83	4.40	22.79	13.66	40.40	30.00	0.84	163.38
Surface water	53.88	–	–	–	–	–	–	–	–	–	53.88
Polk											
Ground water	75.26	20.43	81.50	23.77	3.15	148.30	7.09	1.74	28.15	1.90	391.29
Surface water	–	–	–	–	–	–	–	–	254.78	–	254.78
Sarasota											
Ground water	51.98	–	–	–	3.10	2.08	6.66	34.60	–	1.67	100.09
Surface water	2.71	–	–	–	–	–	–	–	–	–	2.71
Total											
Ground water	177.04	162.81	94.49	26.00	29.91	421.45	56.40	335.43	58.38	5.98	1,366.77
Surface water	185.24	2.10	12.10	–	–	–	–	–	427.58	–	627.02
Saline water	–	–	–	–	–	–	–	–	2,236.84	–	2,236.84

*U.S. Army Corps of Engineers (1977).
**USEPA (1977a).
†SWFWMD (1977).

proposed (see Figure 1.29). Since it is assumed that there will be no change in the production rate or water demands for chemical processing plants, their existing water demands can be projected to the year 2000 without any data reduction.

Water demands for the permitted or existing mines were indicated in subsection C. Water demands for the DRI mines were taken from the DRI applications. A production estimate for the proposed mines was provided in some cases by the Florida Phosphate Council. In other cases, an average 1976 yearly production rate was applied; the production rate was multiplied by the 1976 yearly average gallon per ton of marketable rock to determine water demands for 1985 and 2000. No monthly variation in water demand was assumed since phosphate production generally remains the same throughout the year. Also, when a mine falls within the boundaries of two counties, water demands are applied only to the county in which the mine was assumed to have initially begun operations. The application of water demands from the three categories of mines (Figure 1.29) can be considered a worst-case analysis.

b. Citrus Processing

Projected water demands for citrus processing were extracted from SWFWMD's water-use plan (1977). The Four River Basins study (U.S. Army Corps of Engineers 1977) indicates that citrus processing is expected to be in generally the same locations as present production but that existing facilities will be expanded to meet increased production, thus creating increased water demand. Water demand peaks from October through April and drops to 20 percent of peak values during the remainder of the year.

c. "Other" Industries

Projected water demands for "other" industries (defined in subsection C) were extracted from SWFWMD's Water Use Plan (1977).

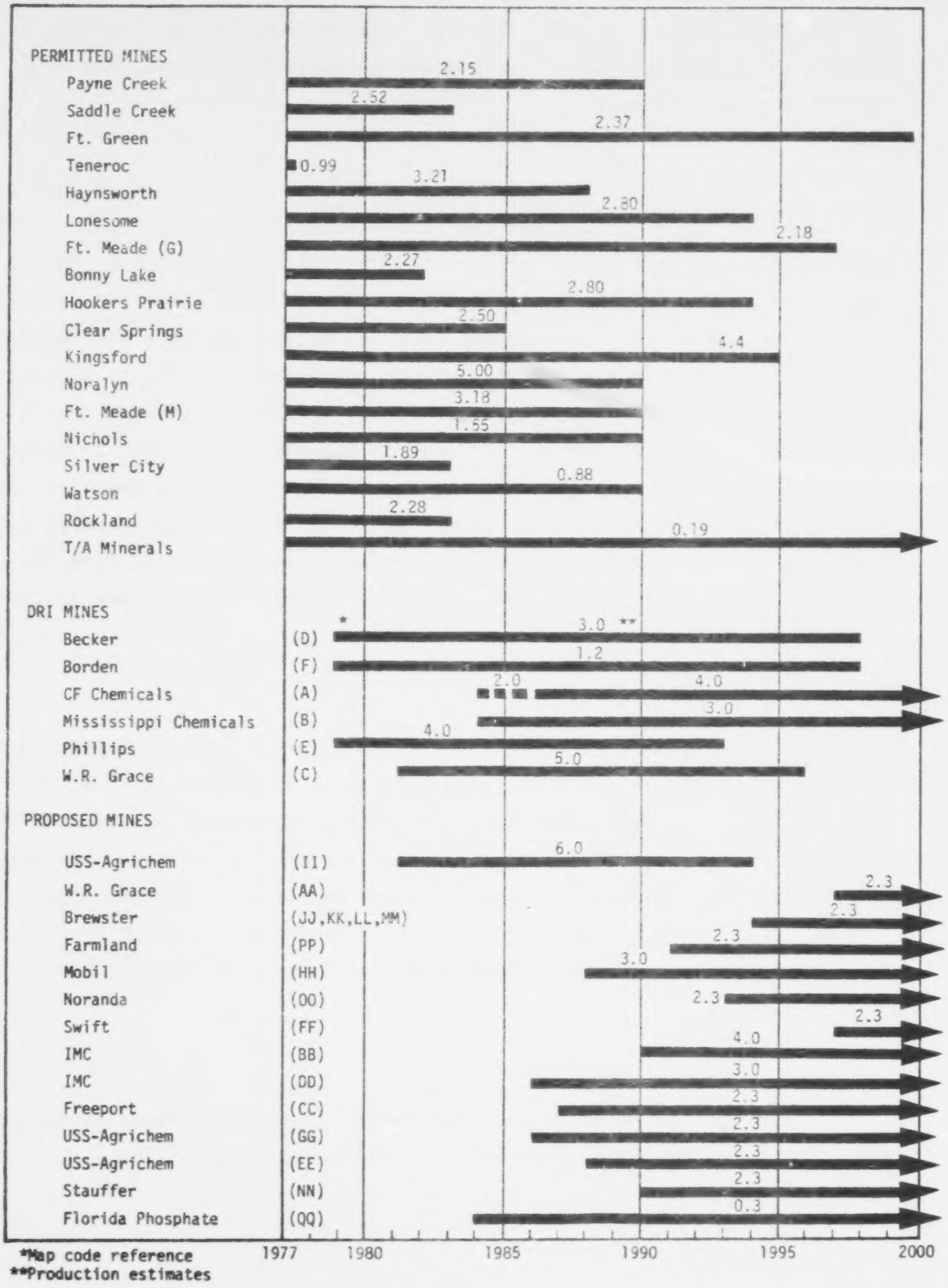


Figure 1.29. Projected Life and Production Rates for Central Florida Phosphate Mines

3. Agricultural

Projected agricultural water demands were taken from the Four River Basins study (U.S. Army Corps of Engineers 1977).

Improved irrigation efficiencies that include subsurface (seepage) and sprinkler irrigation are likely to result from research presently underway. Currently, subsurface and furrow irrigation account for about 57 percent of the total irrgated acreage in Florida. Most of the commercial vegetable and pasture acreage utilizes this system, which is considered to be from 50 to 60 percent efficient. Sprinkler irrigation, which is from 70 to 75 percent efficient, is used on about two-thirds of the irrigated citrus fields in the state.

Drip irrigation, a relatively new technique, has been used on about 8,000 acres of citrus and other crops since 1971 and, according to investigators, has significantly increased crop yield. Most of the citrus irrigation in 1975 was 75 percent efficient, whereas most cropland and pastureland irrigation (which uses the seepage system) was about 50 percent efficient.

4. Miscellaneous

a. Power Production

The planning horizon of the power industry with respect to siting future plants allows projections only to 1985; the year 2000 is beyond the time within which companies usually plan locations of generating facilities. Water-demand data for projections were obtained by personal communication between company representatives and Tomasino & Associates of Temple Terrace, Florida.

Since future plants are expected to be located near coastal areas, permitting the use of saline water for cooling, water demands (Tables 1.26 and 1.27) are not expected to change significantly; however, it is assumed that the DeSoto site will be operating.

b. Golf Courses

Projected water demands for golf courses (Tables 1.26 and 1.27) are taken from the Four River Basins study, which uses DRIs and an average water-use factor of 4 million gallons per year per acre as representative of the historical use of water on Florida golf courses (U.S. Army Corps of Engineers 1977).

5. Summary

Table 1.28 summarizes projected water demands relative to those of 1976.

Table 1.28. Total Present and Projected Water Demands by County

	Demand (mgd)				
County	1976	Projected 1985	Change 1976-85	Projected 2000	Change 1976-2000
Charlotte	26	31	5	43	17
DeSoto	109	316*	207	366	257*
Hardee	190	232	42**	352	162
Hillsborough	180	248	68†	268	88
Manatee	113	166	53†	217	104
Polk	740	739	-1	646	-94‡
Sarasota	56	70	14	103	47

*Reflects assumed power-plant operational status.

**Reflects large increase in projected irrigation pastures.

†Increase mining activity.

‡Decrease in mining activity.

a. 1985

As indicated in Table 1.26, the average estimated water demand for the study area in 1985 will be approximately 1,801 million gallons per day (excluding saline water). Polk and Hillsborough counties will have the highest demands. DeSoto County's high demand is somewhat misleading since the increase assumes the operational status of the Florida Power & Light plant site.

The municipal classification will account for approximately 275 million gallons per day, or approximately 15 percent of the study area's total, with Polk and Hillsborough counties having the highest demands and DeSoto and Hardee the lowest. Industry will require an estimated total of 370 million gallons per day, or about 21 percent of the study area's total. The major user in this category, the phosphate industry, will need 317 million gallons per day, or approximately 86 percent of the total industrial demand, which represents an increase of 44 million gallons per day over 1976 demand. Citrus processing will increase from 1976's 20 million gallons per day to 23 million gallons per day, while other industries will increase from 24 to 29 million gallons per day.

The total estimated water demands for agriculture in 1985 will be 665 million gallons per day, or about 38 percent of the study area's total, representing an increase of 56 million gallons per day over 1976. Citrus and pasture irrigation will increase whereas truck-crop irrigation will decrease. In the "miscellaneous" category, the various power plants will require 486 million gallons per day and golf courses 5 million gallons per day.

b. 2000

Projected freshwater demands for the study area in 2000 (Table 1.27) are 1,994 million gallons per day. The municipal category's 362 million gallons per day represents 18 percent of the study area's total, which is 2 percent higher than the entire industrial class (projected to be 327 million gallons per day, or 16 percent of the study area's total). Again, the phosphate industry will be the highest industrial user with demands of 272 million gallons per day (83 percent of industrial total), representing a decrease of 46 million gallons per day - approximately the same level as 1976 (worst-case analysis). Again, the largest water user in the 7-county study area will be agriculture with 812 million gallons per day, or 41 percent of the study area's total; this is a 45 percent increase - 147 million gallons per day over 1985 values and 200 million gallons per day over 1976 demands.

Freshwater demands for power generating plants and golf courses are not expected to change by any significant amounts.

E. PRESENT AND FUTURE WATER RESOURCES

1. Introduction

Before discussing the study area's present and potential water resources relative to water demand, it should be noted that a detailed water resource management study was beyond the scope of this study. The U.S. Army Corps of Engineers Water Resources Management Study (1977) was selected as the basic source of information considered applicable.

2. Historical Problems

Water demands do not necessarily denote problems. The existing demand, for example, is being met by existing withdrawals, primarily from the Floridan aquifer. The Water Resources Management Study (WRMS 1977) indicates that, with proper water management, large additional amounts of water could be taken from the Floridan aquifer in many parts of the study area without causing significant adverse impact.

Natural factors that can cause water problems are poor chemical quality of local water resources, inadequate local freshwater resources, and inadequate carryover storage space for water during periods of deficient rainfall. Man-made constraints on water development can be classified as regulatory, sociopolitical, and economic. Unlike the natural constraints, the man-made ones are subject to change and can be either relaxed or strengthened, depending on circumstances and changing attitudes.

The geographic distribution of water also presents problems. It is not feasible along any of the coast of the study area to develop very large dependable supplies of water from wells; several cities in the past installed wells close to the shoreline, but these wells began to yield brackish water after relatively short periods of operation and had to be abandoned. Sarasota is an example of a city that presently obtains its water supply from a well field located almost 20 miles inland; even at this inland location, concentrations of dissolved solids and sulfate exceed recommended limits for public supply.

Inland, no severe water-supply problems have been manifested because water is naturally more abundant and population less dense. However, seasonal and long-term declines of the potentiometric surface in inland localities are causing considerable concern, especially in the more southerly part of the study area; yet, these declines do not appear to have depleted water availability nor to have caused any significant environmental impacts.

The major water problems in the study area (to the year 2035) will be those of municipalities in the coastal zones. Figure 1.30 indicates the specific areas.

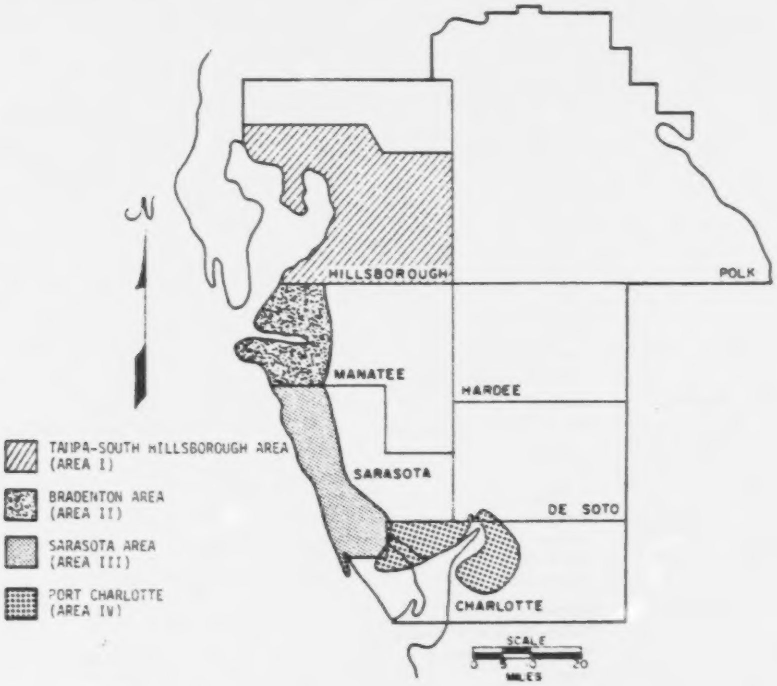

N
HILLSBOROUGH
POLK
MANATEE
HARDEE
SARASOTA
DE SOTO
CHARLOTTE
TAMPA-SOUTH HILLSBOROUGH AREA (AREA I)
BRADENTON AREA (AREA II)
SARASOTA AREA (AREA III)
PORT CHARLOTTE (AREA IV)
SCALE
0 5 10 20
MILES

Figure 1.30. Locations of Water-Demand Areas (modified from U.S. Army Corps of Engineers 1977)

3. Existing Potable Water Resources

The existing potable water systems are indicated in the EPA inventory of water withdrawals (Table 1.23). In addition, Table 1.29 is taken from the WRMS list of municipal systems or well fields (U.S. Army Corps of Engineers 1977). The two lists are not repetitious, nor are they considered to be exhaustive or complete; they do, however, provide an insight into the vast number of systems within the study area. The surface-water systems are more important than the groundwater systems. There are six existing sites on major streams in the study area from which fresh water is withdrawn to the coastal areas. In Table 1.23, these sites are identified relative to location, municipalities served, and daily withdrawal rates.

Table 1.29. Municipal Water Systems by County and Source, 1975*

County	Municipality, System, or Field	Source	
		Ground Water	Surface Water
Charlotte	Punta Gorda		Shell Creek
	Port Charlotte	10%	90% from Fordham waterway
DeSoto	Arcadia	x	
Hardee	Wauchula	x	
Hillsborough	Brandon (purchased June 1975)	x	
	Cosme/Odessa well field (city of St. Petersburg)	x	
	Eldridge-wilde well field straddling Pinellas-Hillsborough line (Pinellas County water system)	x	
	Plant City	x	
	River Oaks	x	
	Riverview	x	
	Ruskin	x	
	Seaboard Utilities	x	
	Section 21 (city of St. Petersburg)	x	
	Sun City	x	
	Tampa		Hillsborough reservoir
	Tampa Suburban Utilities	x	
	Temple Terrace Utilities	x	
Manatee	Bradenton		Ward's Lake
	Manatee County Utilities System		Lake Manatee reservoir
Polk	Auburndale	x	
	Bartow	x	
	Ft. Meade	x	
	Haines City	x	
	Lakeland	x	
	Lake Wales	x	
	Winter Haven	x	
Sarasota	Englewood	x	
	Florida Cities Water Company	x	
	North Port Charlotte		Big Slough canal
	Sarasota	x	
	South Gate Water & Sewer Company	x	
	Venice	x	

* U.S. Army Corps of Engineers (1977).

4. Projected Surface-Water Resources

The WRMS study chose 28 sites (Plate 3) of potential surface-water supply. The ones showing the best potential for a reservoir are:

- Peace River-Charlie and Limestone creeks
- Peace River-Whidden Creek
- Alafia River-Fishhawk Creek
- Alafia River-South Prong
- Lake Manatee
- Horse Creek
- Lower Hillsborough River detention area

Those appearing to be best for interbasin transfer potential are the upper Hillsborough River detention area, Horse Creek, Alafia River-South Prong, and Peace River-Charlie and Limestone creeks.

5. Potential Solutions to Water-Supply Problem

The four principal solutions to water-resources problems in the study area include groundwater well-field development, excess surface-water storage, piping of excess surface flow, and injection of excess surface flow into the aquifer for retrieval. These solutions constitute 15 independent alternative plans. The plans that pertain to the study area are as follows:

- Groundwater well field development
    - Pipe water-table aquifer water to Port Charlotte from Telegraph Swamp by using a catchment area that would intercept 15 percent of the average annual precipitation (since the pumped water would essentially come from surface-water runoff and not from the Floridan aquifer) or by locating 60 wells spaced 1,000 feet apart over 1,860 acres.
    - Locate a well field in the Little Withlacoochee flood detention area to provide water to the Tampa-South Hillsborough area, spacing 25 wells 1,000 feet apart and connecting the system to the existing Cypress Creek well field and then delivering to the city of Tampa for further distribution.

- Locate a field of 14 wells spaced 1,000 feet apart in southwestern Polk County to deliver water supply to the Bradenton area.
- Locate three well fields - the farthest to be midway between Ona and Ft. Green, the next one to be at the Horse Creek site, and the nearest to be at the Long and Ogleby creeks site - and connect them by pipeline to the existing Verna well field to supply the Sarasota area.

- Excess surface-water storage
  - The Tampa bypass canal would provide water supply to the Tampa reservoir during dry conditions. Part of the canal upstream of S-162 would capture aquifer flow and be pumped and diverted into the Hillsborough River. The desired elevation would be 15.0 feet, mean sea level. To prevent increased salinity intrusion, especially at S-160, if pumping were year-long, water that had undergone advanced wastewater treatment at the Hooker's Point treatment facility would be piped upstream of S-160 to maintain a higher than 10-foot msl head. S-160 would require modification. The higher head would act as a freshwater barrier and convert the reach between S-160 and S-162 from a discharge area to a recharge area. Environmental impact assessment would center around salt intrusion at the lower (10-foot msl) level, and the question concerning water quality would be addressed.
  - The Fishhawk Creek site on the Alafia River would provide 41 million gallons per day to a considered treatment facility at Wimauma, where 25 million gallons per day would be treated and distributed to the south Hillsborough area; the remaining untreated 16 million gallons per day would be provided to the Lake Manatee water-treatment plant for treatment and distribution to the Bradenton area. Alafia River water quality would be evaluated.
  - The Charlie-Limestone creeks site on the Peace River would provide 54 million gallons per day; of this, 30 million gallons per day would be piped to the Port Charlotte area and 24 million gallons per day to the Verna well field for treatment and supply to the Sarasota area. Peace River water quality would be evaluated.
  - The Horse Creek site would supplement the above plan, piping 14 million gallons per day along with the 24 million gallons per day to the Verna well field.

- Piping of excess surface flow
  - Pipe excess surface flow of the Suwannee River (350 million gallons per day), beginning at Fannin on the Suwannee River and flowing southward to four demand areas: Eldridge-Wilde well field outside of the study area, the city of Tampa, Lake Manatee, and the city of Sarasota. The areas could combine funds and construct one major pipeline, thereby reducing costs.

- Injection of excess surface flow into the aquifer (groundwater storage and retrieval)
  - Lake Manatee. The plan calls for a diversion structure at Lake Manatee and piping of the water to a nearby injection-recovery facility. Only excess surface water would be injected.
  - Tatum Sawgrass. This would be an excess surface-water detention site on the Myakka River to provide water for injection near the Sarasota area.
  - The Charlie and Limestone creeks site. This would be an excess surface-water detention site on the Peace River to provide water for injection near the Port Charlotte area.

All injection plans would be evaluated with respect to water quality.

The following is an excerpt from the summary, conclusions, and recommendations chapter in the hydrologic and engineering evaluation (U.S. Army Corps of Engineers 1977):

> "Despite the availability of sufficient surface- and groundwater resources to meet the projected water-supply demands of the population to the year 2035, localized water shortages undoubtedly will occur and water quality problems will probably develop. However, hydrologic and engineering solutions for such problems are available, and most probably will involve the conveyance of water from areas having a surplus to areas having a deficiency. The successful implementation of the solutions ultimately depends on economic, environmental, and socio-political constraints - in other words, the problems are not purely of a scientific or engineering nature, but are essentially people and money problems."

Other solutions for freshwater supplies are also being considered, e.g., wastewater reuse and desalination.

Reusing treated sewage effluent and other industrial wastewater is not widely practiced at present because of the possibility that the wastewater may contain organisms or mineral constituents potentially harmful to man and his environment. However, treated wastewater is too expensive and of too high quality to be discharged wastefully into the ocean or other bodies of water. Wastewater is not limited to direct human reuse but instead may be used by industry and public parks and for irrigation, golf courses, and lawns.

As a result of modern technology, desalination (converting saline water into fresh water) is now becoming much more competitive with traditional water-resource development. The Southwest Florida Water Management District considers desalination (at least through its 2020 planning period) to be a viable method of water supply in only one area - the coastal region of Charlotte and Sarasota counties. However, the SWFWMD does recognize that desalination could be feasible in other areas under certain conditions.

F. WATER MANAGEMENT

1. General

Statutes governing water management in Florida are numerous and complex: they change as new situations arise. Agencies responsible for the quantitative management of water include local soil and water conservation districts, local drainage districts, Florida water management districts, the Florida Department of Environmental Regulation, and the U.S. Army Corps of Engineers. Agencies responsible for the qualitative management of water include the Floridan environmental district centers, the Florida Department of Environmental Regulation, and the U.S. Environmental Protection Agency. Table 1.30 is a guide to state statutes.

2. Water Resources Act of 1972

The 1972 Florida Water Resources Act provides for the comprehensive state regulation of all types of water resources, including ground and surface water, within the framework of a riparian water law system (Maloney nd). Under the doctrine of riparian rights, equal rights to the use of water are given to the owners of land bordering or touching a stream or watercourse. The Florida system includes a 2-tiered administrative structure with overall state-level supervision plus regulatory implementation by five water management districts, the boundaries of which are based on hydrological rather than political considerations. The law mandates development

Table 1.30. Florida Statutes*

	Chapter.Subsection	Subject
Drainage, Water Management	298.01	Formation of water management (drainage) districts; purposes
	298.26	Filing of annual reports and water management plans with DER
	298.29	Levy and collection of taxes
	298.35	Powers of supervisors to carry out "the plan of reclamation"
Water Resources	373.026	General powers and duties of the DER
	373.043	Adoption and enforcement of regulations by the department
	373.046	Interagency agreements for water management purposes
	373.047	Cooperation between districts
	373.069	Creation of water management districts
	373.191	County water conservation projects
	373.1962	Regional water supply authorities
Public Health	381.031(1)(g)(3)	Powers to pass rules and regulations relating to sanitary practices and drinking water, public water supplies, and disposal of sewage
	381.2	Public health (under Department of Health and Rehabilitative Services)
	381.261	Division of Health; general supervision and control over all systems of water supply, sewage, refuse, and sewage treatment as they affect public health
Air, Water Pollution Control	403.061	Powers and duties of DER
	403.087	General issuance of permits
	403.088	Water pollution operation permits
	403.182	Local pollution control programs, county, municipality, or combination
	403.808	Powers and duties of Division of Environmental Permitting
	403.809	Environmental districts (colocated if possible with water management districts)
	403.812	Delegation of functions to water management districts provided district has financial and technical capability
	403.813	Permits issued at district centers
Soil, Water Conservation	582	Soil and water conservation districts
	582.01(1)	Definition of soil and water conservation district
	582.20	Power of districts and supervisors
	582.28	Cooperation among soil and water conservation districts
	582.29	State agencies to cooperate with soil and water conservation districts
	582.331	Establishment of watershed improvement districts within soil and water conservation districts**
	582.43	Status and general powers of watershed improvement district
	582.44	Levy of taxes by watershed improvement districts
	582.47	Coordination of watershed improvement districts with flood control districts

*Institute of Food and Agricultural Sciences.

**Under Florida law, watershed improvement districts are subdistricts of one or more soil and water conservation districts. The 20 watershed improvement districts in Florida were established primarily to handle local flooding problems. Only the watershed improvement districts have taxing authority.

of an overall state water plan based on water use as well as water quality; it also provides for consumptive-use permits based on a standard of reasonable-beneficial use designed to combine the best features of the riparian and prior-appropriation approaches. A use to be permitted must be both economically efficient and reasonable as well as in the public interest. The two cardinal principles of the doctrine of prior appropriation are that beneficial use of water, not land ownership, is the basis of the right to use water and that priority of use, not equality of right, is the basis of water between appropriators when there is an inadequate supply.

The Florida system gets its necessary flexibility by using fixed-term permits rather than the in-perpetuity permits of the prior-appropriation system. It is designed to protect both current user and the rights of future generations while allowing sound, long-range land and water use planning (Maloney nd).

One of the most important features of Florida's 1972 Water Resources Act is its requirement for the development of an overall state water use plan and a state water-quality plan. The state water plan is administered by the Department of Environmental Regulation, which has statewide jurisdiction over water-use and water-quality planning and regulation. To this end, the FLorida Water Resources Act delineates general objectives that the state water-use plan must seek to implement. The Department of Environmental Regulation is required to give due consideration to:

- Attainment of maximum reasonable-beneficial use of water for environmental protection, fish and wildlife, recreational use, water quality, irrigation, mining, power development, and domestic, municipal, and industrial uses
- Economic development of water resources
- Control of waters for navigation, drainage, and flood control
- The quantity of water available for application to a reasonable-beneficial use
- The prevention of wasteful and unreasonable use of water resources

- Presently exercised domestic use and permit rights
- Water quality and the state water-quality plan
- The state water-resources policy

The act requires that the department ascertain the quantity of water available for application to reasonable-beneficial uses and the extent of presently exercised domestic uses and permit rights; this information must then be considered in the formulation of any plan for future development of the resource. Detailed planning must be based on a thorough study of the state's water resources, including existing use patterns and problems. Another innovative provision in the act is the development of a new standard to govern the issuance of consumptive-use permits by the standard of reasonable-beneficial use; the purpose is to protect other water users and the general public from wasteful uses of water. Issuance of a permit for consumptive water use is governed also by several other provisions of the act: the department is allowed to designate certain uses which are to be given preference in consumptive-use permitting (e.g., recreation, preservation of the environment, protection of recharge areas); and the act provides for the establishment of minimum flow for surface watercourses and minimum lake and groundwater levels.

When the 1972 Florida Water Resources Act established the Department of Natural Resources as the state-level agency charged with regulating the consumptive use of water, the Department of Pollution Control (a separate state agency) was already in charge of water quality. To assure proper coordination of the control of water use and water quality, the 1975 state legislature placed both under a single new environmental agency, the Department of Environmental Regulation.

3. Southwest Florida Water Management District

The agency having the prime responsibility for managing and controlling the quantity of water and allocating water withdrawal and use in the study area is the Southwest Florida Water Management District (SWFWMD) and its regulatory arm, the Southwest Florida Water Management District

(Regulatory). SWFWMD was created on July 1, 1961, by Chapter 61-691, Laws of Florida, and its boundaries modified in 1963 by Chapters 63-659 and 63-849, Laws of Florida. The Florida Water Resources Act of 1972 amended Chapter 373, Florida Statutes, effective October 1, 1974, and specified duties, responsibilities, and authorities of the state water-management districts and redefined their boundaries. Subsequent to this legislative authority, the SWFWMD established its rules and regulations in Chapter 16-J-0, -1, -2, -3, and -4 of the Florida Administrative Code adopted on October 5, 1974, which constitutes the basis of decisions by district personnel. The SWFWMD consists of a 9-member governing board and an executive director and his staff. The area of the district is subdivided into watershed basins, each with its own governing board. The district manages and protects the surface and ground waters within its boundaries by:

- Constructing, owning, and operating water-management, water-conservation, flood-control, and water-supply projects
- Regulating discharges into waters in which it has projects by means of a permitting system and regulating construction within the floodplain of waters it manages
- Regulating the use and withdrawal of surface and ground waters by a consumptive-use permitting system and by water-shortage emergency powers
- Regulating water wells by licensing and bonding well drillers, by a permitting system for new wells, and by setting standards for well construction and abandonment
- Regulating the impoundment and storage of surface waters by a construction and operation permitting system
- Routinely monitoring rainfall, water levels, and potentiometric levels throughout the area

One of the most important activities of the Southwest Florida Water Management District is the control of water use and withdrawal through consumptive-use permits in accordance with Chapter 16-J-2, Florida Administrative Code. This requirement is effective in the Hillsborough River; northwest Hillsborough; the Green Swamp; and the Alafia, Crystal-Homasassa, Pithlachascotee, Peace, Withlacoochee, and Pinellas-Anclote River Basins.

Beginning January 1, 1975, all new water uses must be permitted. Beginning January 1, 1977, all water uses existing prior to January 1, 1975, must also be permitted or have an application for permit pending. In general, permits are required if withdrawal from one source will average more than 100,000 gallons per day, maximum daily withdrawal will or can exceed 1,000,000 gallons per day, withdrawal from a combination of sources can exceed 1,000,000 gallons per day, or withdrawal will be from a well having an inside diameter of 6 inches or more. Permits are not required for individual house-water supplies used only for domestic consumption. In addition, all legal uses of water existing on January 1, 1975, and holders of permits or agreements for consumptive water use issued by the district before July 1, 1973, must be protected as long as the uses are not contrary to the public interest. Water use by electric power generating companies is exempt from district regulation.

Unless specifically exempted by the district governing board, each consumptive-use permit must conform to the following conditions:

- The use must be reasonable, beneficial, and in the public interest and not interfere with other present legal water use
- The use must not lower the rate of flow of a stream or watercourse, the potentiometric level of the artesian aquifer, or the level of the groundwater surface below the minimums set by the board and must not significantly induce saltwater encroachment or adversely affect lake stages or vegetation
- The consumptive use of water (i.e., water removed from the watershed) must not exceed the projected recharge rate of 365,000 gallons per year per acre being served
- The water withdrawal must not reduce the rate of flow of a stream or watercourse by more than 5 percent, the potentiometric level under lands not controlled by the user by more than 5 feet, or the groundwater table under lands not controlled by the user by more than 3 feet, the surface of a lake or other impoundment not completely controlled by the user by more than 1 foot, or the potentiometric surface below sea level

In addition, the district may reserve water from use to protect fish, wildlife, or public health and safety. All legal water uses existing before

January 1, 1975, must be protected as long as this is not contrary to the public interest.

Water uses not considered consumptive are crop irrigation where there is no runoff, water applied to crops for freeze protection, water used in fish farming, and water removed to temporarily dewater construction sites.

If two or more applications for consumptive-use permits are competing for a limited quantity of water, the application that best serves the public interest will be given priority. A renewal application will be given priority over a new application.

The procedure for obtaining a consumptive-use permit is as follows:

(1) Application submission (the preparation of which may require special studies or testing)

(2) Review by the Southwest Florida Water Management District staff

(3) Public notification

(4) An examiner-conducted public hearing on fact and law (staff reports and objections are heard at this time)

(5) Examiner's report

(6) Approval (or denial) of the permit by the governing board at a public meeting

The governing board can place conditions on permits and can temporarily or permanently revoke permits for cause. All permits are classified by source and use.

If a water shortage is publicly declared or there is an emergency due to a water shortage, the district and its governing board can take needed action (e.g., appropriation, rotation, or limiting or prohibiting the use of the water resources) to protect the water resources.

SECTION 2

WATER QUALITY

A. INTRODUCTION

The baseline water quality in the study area is described in this section of the volume dealing with water. Specifically, the surface water quality for appropriate stream segments is characterized, sites of violations of water quality standards are indicated and located on a map, major point and nonpoint sources of pollution are identified, future phosphate industry water quality parameter loadings are projected, available groundwater quality data are summarized, and historical problems are discussed. This baseline characterization of water quality in the 7-county study area provides a basis for assessing the effects under various scenarios of the activities of the phosphate industry in westcentral Florida. All information regarding the existing and historical water quality of the area was derived from existing data.

In the attempt to assess the water quality of the area with existing data bases, noncontinuous and incomplete water quality records for many of the stream segments within the study area presented some problems, as did the paucity of data that was to have been provided by the "208 planning agencies" regarding present and projected water quality within the study area. The characterization relied heavily on STORET (USEPA 1977b), a computerized data-base utility maintained by the EPA for the storage and retrieval of parametric data relating to the quality of the waterways of the United States published from state and private agency reports and draft data from regional planning agencies. STORET capabilities were less than anticipated, so a great deal of hand calculation and summarization by TI personnel was necessary.

Areas where water quality violations existed were determined by applying Florida water quality standards to the summary data compiled from STORET output for each stream segment investigated. Point and nonpoint sources of pollution were determined primarily from the Peace River and Tampa Bay Area Water Quality Management plans (Florida Department of

Environmental Regulation 1976) and a draft document for the Tampa Bay Regional Planning Council (TBRPC) "208 plans" (Tampa Bay Regional Planning Council 1977a). The discussion of groundwater quality and historical problems of ground water within the study area is based on a summary of pertinent literature, most of which evolved from federal, state, and county agency investigations.

B. SURFACE WATER

1. Characterization of Water Quality in 7-County Study Area

a. Introduction

To characterize the water quality of the 7-county study area accurately using STORET data, TI considered the number and locations of sampling stations for which appropriate water quality data were available and the comparability of the data available for all of the stations (i.e., the number of observations for each parameter and the time period over which the data were collected). To characterize the study area's water quality by a method that would allow assessing the effects of phosphate industry activities, each of nine rivers as well as Charlotte Harbor and Tampa Bay were partitioned into segments (Plate 1) based on water use classifications and STORET data availability. Stream segments and the sampling stations that provided water quality data for each segment are listed in the Appendix.

STORET water quality data for the sampling stations were accessed and the water quality characteristics for each of the appropriate segments determined. The average values and ranges are presented on Plate 4 in the map pocket.

b. Overview

The surface water quality in the study area is greatly influenced by the flow patterns of the streams and rivers. Generally higher mineral content (evidenced by higher total dissolved solids and higher specific ion concentrations) occurs during the dry period (considered to be October-May) than during the wet season (June-September). The flow of most of the study area's rivers is highly variable and may vary greatly within a short period. This variability is particularly evident along the Peace River where overland runoff is a predominant contributor to increased flow. The Southwest Florida Regional Planning Council (1977) has provided evidence that the flow of the Peace River at Arcadia in the past has increased 500 percent in a single day. For all of the other major streams within the study area except the Peace River, little or no flow occurences have been recorded.

Within the study area, an inverse relationship has been found between river discharge and salinity and dissolved oxygen (Dragovich et al 1968). The large input of freshwater during the rainy season from both overland runoff and the water-table influence dilutes the rivers, causing decreased salinity values. Dragovich et al (1968) found that plant production heavily influenced dissolved-oxygen concentrations and that concentrations were highest at stations having the highest chlorophyll a concentrations (P.11, A.12, and H.4 in their investigation from January 1964 to January 1965). During increased river discharge (wet season, June-September), dissolved-oxygen concentrations in many of the rivers in the study area decrease due to both the dislodging of submerged aquatic flora and the influx of increased quantities of organic material (humus from forest beds, swamp flushings, livestock areas runoff) via surface runoff, which has a high biochemical oxygen demand. Dragovich et al (1968) found that the rivers in the study area contribute substantial organic material to the Gulf of Mexico, especially during periods of heavy rainfall. This same phenomenon of decreased dissolved oxygen with increased discharge was observed in a study by Texas Instruments along the Peace River (TI 1977). The influence of photosynthesis (related to the concentration of chlorophyll a) on the dissolved-oxygen concentrations is supported by the variation in dissolved-oxygen concentrations noted on Plate 4 (in map pocket) for segments which Dragovich et al (1968) identified as having high chlorophyll a concentrations (i.e., segments P.11, A.12, and H.4, which have dissolved-oxygen ranges of 2.3-11.8, 0.3-12.8, and 1.5-8.6 respectively).

Groundwater contribution to river flow and water quality is particularly evident within the study area as the base flow of nearly all of the streams consists of seepage from both the water table and the Floridan aquifers. About 50 percent of the Alafia River's average flow is from groundwater discharge, but this may decrease to approximatey 30 percent during a wet year and increase to more than 60 percent during a dry year (Borden 1975). The various springs in the area (refer to Section 1 of this volume) generally reflect the water quality of the groundwater aquifer from which they originate, and their influence is often evident in the nearby surface-water quality, with the greatest influence being evident during the dry season.

Domestic and industrial discharges may greatly influence the flow (and the resultant water quality) of some of the rivers, particularly the Peace and Alafia which receive the majority of the wastewater discharges from the central Florida phosphate industry activities. In 1952, the Florida State Board of Health estimated that the volume of phosphate-containing effluent from phosphate industry activities above Ft. Meade composed 60 percent of the volume of the Peace River flow at Ft. Meade (Tampa Bay Regional Planning Council 1977).

The following parameter ranges characterize the surface-water quality of the study area (U.S. Army Corps of Engineers 1977).

Total dissolved solids (TDS)	61-409 mg/l
Hardness	34-264 mg/l
Sulfate	6-198 mg/l
Chloride	3-23 mg/l
pH	5-8 pH units
Color	0-280 Pt-Co units
Phosphate	0.4-3.9 mg/l
Turbidity	0-350 JTU's

Figure 2.1 indicates the dominant cations and anions associated with the springs and streams in the study area. Much of the study area is the calcium and magnesium bicarbonate type, which is indicative of runoff from soils particularly rich in limestone, dolomite, or gypsum. Water in

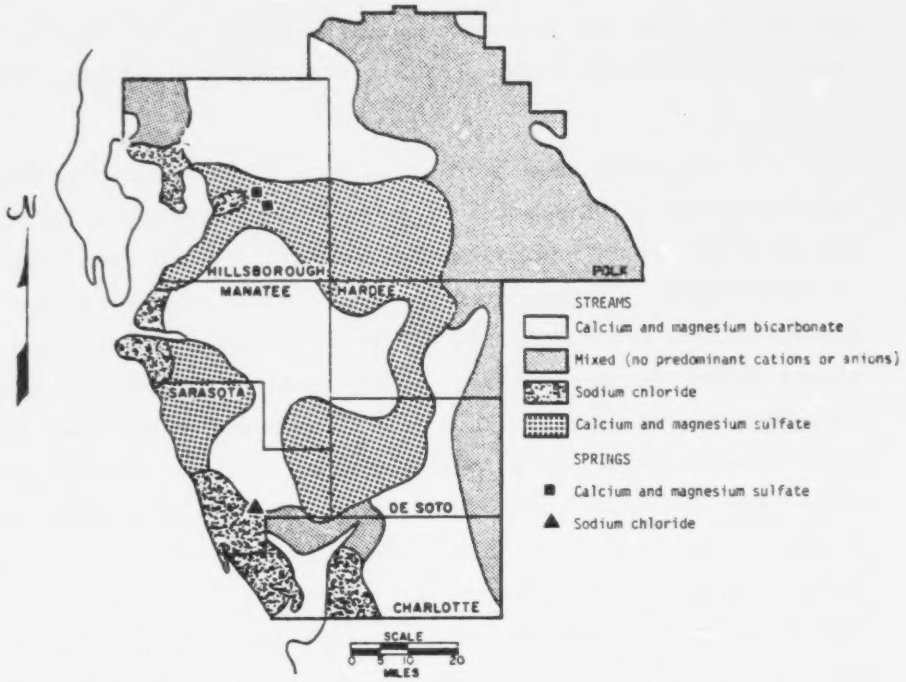

N
HILLSBOROUGH
MANATEE
HARDEE
POLK
SARASOTA
DE SOTO
CHARLOTTE
STREAMS
Calcium and magnesium bicarbonate
Mixed (no predominant cations or anions)
Sodium chloride
Calcium and magnesium sulfate
SPRINGS
Calcium and magnesium sulfate
Sodium chloride
SCALE
0 5 10 20
MILES

Figure 2.1. Chemical Types of Water
(U.S. Army Corps of Engineers 1977)

the upper Peace River Basin is the mixed type, indicating contributions from noncarbonate terrains, rainfall, soils, and the water-table aquifer. Much of the water in the Peace River lowland and the Alafia River Basin is the calcium and magnesium sulfate type, which is indicative of aquifer waters, industrial effluents, and agricultural runoff. In the coastal estuaries is the highly mineralized sodium-chloride type of water, indicative of both tidal-water influence and saltwater encroachment.

The natural chemical quality of surface-water bodies has experienced degradation in the form of increased mineralization and turbidity resulting from accidental or intentional releases of pollutants directly into streams or lakes through point discharges, failure of retaining dams around treatment ponds, overland runoff, and inflow from contaminated aquifers hydraulically connected to the streams and lakes. Citrus processing and phosphate mining and chemical processing effluents are released predominantly into the Peace and Alafia rivers. Toler (1967) reported maximum fluoride and phosphate concentrations in the Alafia River at Lithia to be 30 and 192 milligrams per liter respectively during 1964-1965.

The study area's major surface water quality problems are high concentrations of nutrients (nitrogen and phosphorus); low dissolved oxygen and pH; high color; and high total suspended solids and organic and fluoride concentrations. Dragovich et al (1968) found that total and orthophosphorus concentrations decreased from upstream to downstream stations and were higher in the Peace and Alafia rivers than in the Hillsborough, Little Manatee, Manatee, or Myakka rivers - and essentially this same pattern is indicated by the limited data for ortho- and total phosphorus presented on Plate 4 and by the TI (1977) data on the Peace River. The loading of phosphorus to the study area's rivers and estuaries has been found to be greater during the wet season when runoff is maximum than during the dry season when the phosphorus concentrations themselves may be higher due to a greater percentage contribution of phosphorus-containing discharges to the total flow and the greater mineral content resulting from evaporation. Dragovich et al (1968) concluded that the quantity of phosphorus carried by the rivers to the bays and sea adjacent to the study area generally depends more on the volume of the river flow than on the rivers' concentrations of phosphorus; the exception noted was the Alafia River which, although having a flow less than that of the Hillsborough River, adds a much higher total quantity of phosphorus to Hillsborough Bay than does the Hillsborough River. The higher-than-expected phosphorus concentrations in the Alafia River have been attributed to effluents from phosphate industry activities along that river.

Dragovich et al (1968), in his 1965-66 investigation, estimated the following daily contributions of phosphorus to the adjacent sea or bay:

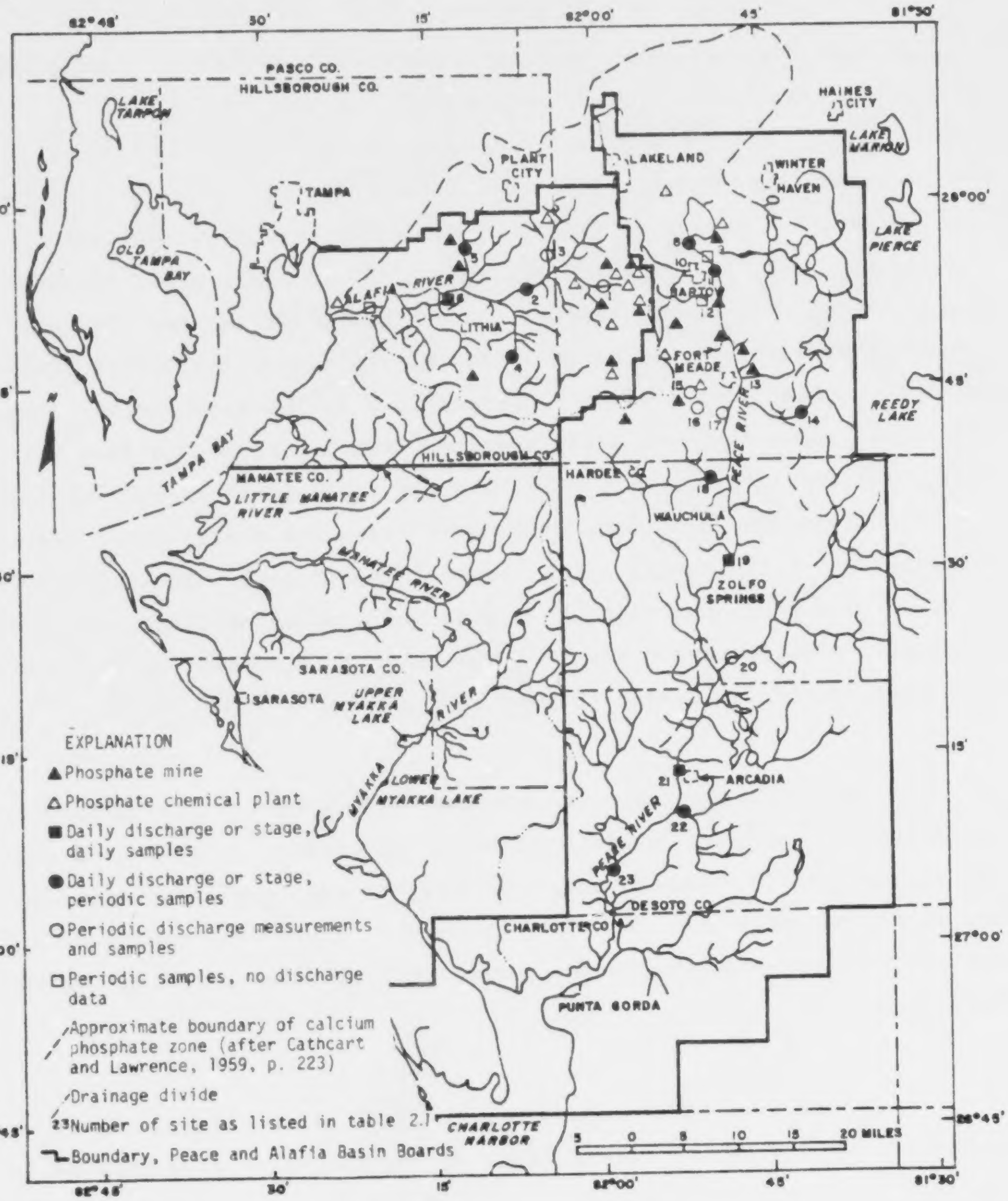
River	Metric Tons/Day	Pounds/Day
Hillsborough	0.725	1598.5
Alafia	0.800	1764.6
Little Manatee	0.150	331.7
Manatee	0.063	139.5
Myakka	0.107	236.2
Peace	2.072	4568.9

The higher phosphorus concentrations were in the rivers which have the most calcium phosphate in their riverbeds and which flow through the Hawthorn phosphatic formations (see Volume VI of this series of working papers).

As this series of working papers discusses later (see Volume VI), fluoride occurs in close association with the phosphate matrix in Florida. Toler (1967) investigated the fluoride content of the Peace and Alafia rivers from October 1964 to September 1965 in an attempt to determine the influence of phosphate mining on the water quality of the area. The Alafia and Peace have received waste from the industry since phosphate mining began in southwest Florida in the late 1800s and are the only rivers presently draining the major phosphate mining activities within Florida. Toler found that fluoride ion concentrations in the Alafia River at Lithia and in the Peace River at Arcadia ranged from 3.2 to 30 and from 0.6 to 2.2 milligrams per liter respectively, whereas the natural background fluoride ion concentrations in streams within the Peace and Alafia River Basins but distant from active mining sites ranged from 0.2 to 0.4 milligrams per liter. Toler concluded that the mining and processing of phosphate rock had apparently affected the quality of the water at all sampling stations along the Peace and Alafia rivers (Figure 2.2 and Table 2.1).

Water discharged from phosphate mining operations is essentially sediment-laden and, in regard to chemical pollutants in dissolved solids, is not of bad quality, whereas water discharged from chemical processing plants may be of extremely poor quality. Table 2.2 shows the results of a chemical analysis of water from a phosphate chemical plant settling lagoon in Polk County.

Since most of the phosphate chemical processing plants are located in the headwaters of the Alafia River Basin, the water from streams in this basin contains higher concentrations of fluoride and phosphate than that from the Peace River Basin. Toler observed peak fluoride loads in August 1965 during peak discharge. The high fluoride loads during high discharge were thought to be caused in large part by either the deliberate or accidental release of larger amounts of wastewater from phosphate settling


82°45'
30'
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PASCO CO.
HILLSBOROUGH CO.
LAKE TARPON
TAMPA
PLANT CITY
LAKELAND
HAINES CITY
LAKE MARION
WINTER HAVEN
LAKE PIERCE
OLD TAMPA BAY
ALAFIA RIVER
LITHIA
BARTOW
FORT MEADE
REEDY LAKE
TAMPA BAY
N
HILLSBOROUGH CO.
MANATEE CO.
HARDEE CO.
LITTLE MANATEE RIVER
WAUCHULA
PEACE RIVER
MANATEE RIVER
ZOLFO SPRINGS
SARASOTA CO.
SARASOTA
UPPER MYAKKA LAKE
RIVER
LOWER MYAKKA LAKE
MYAKKA
ARCADIA
PEACE RIVER
DE SOTO CO.
CHARLOTTE CO.
PUNTA GORDA
CHARLOTTE HARBOR
5 0 5 10 15 20 MILES
1
2
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23
EXPLANATION
▲ Phosphate mine
△ Phosphate chemical plant
■ Daily discharge or stage, daily samples
● Daily discharge or stage, periodic samples
○ Periodic discharge measurements and samples
☐ Periodic samples, no discharge data
Approximate boundary of calcium phosphate zone (after Cathcart and Lawrence, 1959, p. 223)
Drainage divide
23 Number of site as listed in table 2.1
Boundary, Peace and Alafia Basin Boards

Figure 2.2. Location of Sampling Sites on Streams and Area of Phosphate Mining and Processing (Toler 1967)

Table 2.1. Chemical Analyses of Surface Waters in Alafia and Peace River Basins during Relatively Low and High Discharge* (Page 1 of 2)

Basins	Sta.	Date (1965)	Discharge (cfs)†		Parameters (ppm)															Hardness as $CaCO_3$					
					SiO_2	Fe	Al	Ca	Mg	Na	K	HCO_3	SO_4	Cl	F	NO_3	PO_4	TDS		Ca-Mg	NC	Sp Cond @ 25°C††	pH††	Color††	Temp††
Alafia	1	6/02	I	35	80	0.14	-	56	102	52	3.0	0	472	35	17	13	224	1,050		560	560	1,150	4.4	20	81
		9/13	I	77	98	0.20	2.6	111	15	66	3.0	0	340	22	24	3.6	112	810		338	338	1,000	4.6	40	82
	2	6/02	M	79	64	0.17	0.9	126	20	53	2.8	0	300	42	16	0.9	158	802		397	397	930	6.5	20	80
		9/14	M	128	70	0.21	-	94	13	62	4.1	1	232	48	19	9.9	108	661		288	287	788	4.7	40	80
	3	6/02	I	0.2	14	0.00	-	27	19	12	2.5	134	29	21	3.1	0.0	5.8	199		144	34	310	7.8	10	79
		9/13	I	10	19	0.05	0.6	22	7.6	26	8.4	54	19	48	5.2	0.8	13	196		86	42	350	7.0	40	79
	4	6/02	M	20	15	0.23	0.0	46	12	30	1.2	0	100	32	7.8	0.2	86	369		164	164	465	6.6	40	80
		9/14	M	117	30	0.14	2.3	40	8.8	26	2.9	1	88	26	11	0.0	88	326		136	135	370	5.9	100	81
	5	6/02		-	3.3	0.03	-	25	4.4	15	0.2	79	32	10	0.5	0.0	0.7	130		76	11	230	7.6	20	80
		9/14	M	6	8.4	0.19	-	12	4.5	8.9	1.0	37	20	12	0.7	0.4	1.8	88		48	18	150	7.0	90	-
	6	6/02	M	137	54	0.10	-	106	18	44	1.9	0	250	35	13	0.0	143	665		338	338	810	6.5	20	80
		9/14	M	341	45	0.16	2.5	63	9.9	40	3.4	3	152	36	14	7.9	86	461		198	195	688	5.4	85	80
	7	9/14		-	21	0.05	-	199	18	3230	507	63	772	5470	7.4	5.6	8.7	10,300		570	519	16,800	6.7	40	80

*Analyses by USGS (Toler 1967). See Figure 1.32 for station locations.

†Average daily discharge.

††Specific conductance measured in μmho/cm, pH in pH units, color in Pt-Co, and temperature in °F.

I - instantaneous discharge measurement; M - average daily discharge.

Table 2.1. (Page 2 of 2)

Basins	Sta.	Date (1965)	Discharge (cfs)	SiO$_2$	Fe	Al	Ca	Mg	Na	K	HCO$_3$	SO$_4$	Cl	F	NO$_3$	PO$_4$	TDS	Hardness as CaCO$_3$ Ca-Mg	Hardness as CaCO$_3$ NC	Sp Cond @25 C	pH	Color	Temp
Peace	9**	6/01	0	14	0.02	-	38	19	27	1.4	100	116	7.0	3.1	0.1	8.0	283	173	91	470	7.3	5	85
		9/14	M 188	14	0.04	-	22	6.4	20	2.7	68	37	21	1.1	1.5	2.7	161	82	26	242	7.0	80	83
	10	6/01	I 9.4	18	0.09	-	58	19	23	0.6	94	122	34	2.9	1.1	16	340	224	147	525	7.7	10	91
		9/13	I 19	19	0.00	2.6	3.5	1.3	258	5.0	227†	280	32	11	0.6	18	664	14	0	1,400	9.9	20	80
	11	6/01	M 23	12	0.05	-	46	15	34	1.0	91	119	32	2.6	0.0	6.8	313	177	102	515	7.5	10	86
		9/14	M 218	17	0.04	-	31	8.2	21	2.6	50	64	23	2.1	3.2	16	213	111	70	320	6.8	80	82
	12	6/01	I 8.5	13	0.01	-	43	20	54	0.4	154	144	15	3.2	0.4	1.8	371	190	64	635	7.8	5	87
		9/14	I 32	5.5	0.01	0.5	39	12	30	0.3	92	105	11	2.6	0.4	4.5	255	147	72	480	7.2	20	85
	13	6/01	-	18	0.07	-	43	15	15	1.0	138	70	10	1.1	1.2	2.0	244	169	56	405	7.5	10	-
		9/14	-	14	0.09	-	27	9.8	19	2.4	63	51	18	1.4	5.7	6.4	186	108	56	280	6.9	80	83
	14	9/14	M 6.4	6.3	0.22	-	3.0	2.8	6.4	0.8	6	4.0	12	0.2	3.3	.7	43	19	14	79	5.7	160	78
	15	6/02	I 0.8	15	0.00	-	42	15	5.8	0.5	120	64	5.5	3.8	0.1	1.7	212	168	70	340	7.9	5	108
		9/14	I 0.7	20	0.00	-	62	16	6.8	0.8	140	83	8.0	3.1	0.1	13	282	220	106	455	7.5	5	87
	16	6/02	I 3.2	33	0.08	-	30	81	44	0.8	0	392	15	7.3	1.1	156	760	408	408	885	6.3	15	82
		9/14	I 5.2	33	0.18	3.1	64	18	34	1.0	0	210	12	7.0	0.2	131	511	234	234	620	4.6	70	87
	17	6/02	I 24	18	0.01	-	50	30	24	0.4	81	184	16	2.6	0.4	33	398	248	182	576	7.7	15	76
		9/14	I 69	18	0.05	0.6	40	13	16	1.2	28	106	13	4.2	0.1	36	311	154	154	390	7.0	40	-
	18	6/01	M 5.2	2.5	0.19	-	16	7.5	11	0.1	42	34	12	0.8	5.2	2.0	112	71	36	210	7.4	20	78
		9/14	M 52	7.8	0.32	-	13	4.9	8.0	0.8	25	24	14	0.9	1.4	3.7	91	52	32	152	6.7	110	78
	19	6/01	M 59	12	0.05	-	49	17	26	1.2	101	119	16	2.0	1.0	9.7	302	192	109	515	7.6	10	84
		9/14	M 531	14	0.09	-	30	9.0	16	2.4	47	64	16	1.7	2.9	8.5	264	112	74	280	6.8	95	81
	20	6/02	M 4.0	3.9	0.12	-	16	6.2	8.8	0.6	62	14	14	0.7	0.0	2.2	98	66	14	185	7.4	40	80
		9/14	M 87	8.8	0.27	-	7.0	4.5	7.5	1.0	21	4.8	13	0.3	0.2	1.6	64	36	19	98	6.5	240	83
	21	6/02	M 74	11	0.03	-	48	17	25	1.8	105	126	18	1.7	0.9	6.3	308	190	104	495	7.6	10	81
		9/14	M 837	12	0.12	-	25	8.6	13	1.8	55	46	16	1.7	1.4	8.8	161	98	53	245	6.8	110	83
	22	9/14	M 28	8.8	0.46	-	33	6.7	16	2.1	91	29	29	0.4	0.6	1.2	172	110	36	288	7.0	100	83
	23	9/14	-	11	0.17	-	23	7.2	12	1.9	56	37	14	1.5	1.0	5.8	143	87	41	232	6.9	100	83

**Chemical analyses for station 9, discharge data for station 8.

†Includes 80 ppm as carbonate (CO$_3$).

Table 2.2. Chemical Analysis of Water from Phosphate Chemical Plant Settling Lagoon, Polk County, Florida*

Parameter	Parts per Million (except sp. cond. pH, color)
Silica	1,180
Iron	87
Aluminum	64
Manganese	2.7
Calcium	1,110
Magnesium	50
Sodium	155
Potassium	12
Total acidity	123
Bicarbonate	0
Sulfate	2,710
Chloride	37
Fluoride	1,410
Nitrate	0.5
Phosphate	7,540
Dissolved solids	14,400
Total hardness	2,980
Noncarbonate hardness	2,980
Specific electrical conductance	10,100 µmhos
pH	2.0 pH units
Color	140 Pt-Co units

*Analysis by USGS (Toler 1967).

lagoons or by the natural ponding of wastewater in flat, swampy, lowlands during low rainfall and the subsequent flushing of these areas during high rainfall.

2. Characterization by Segment

The characteristic water quality of each of the nine rivers and two principal harbors in the study area is closely keyed to the point and nonpoint discharges adjacent to each surface-water body. The point-source discharges discussed in the following paragraphs are identified in Table 2.3 and their locations shown on Plate 1. The data were obtained by combining information from the Florida Department of Enviromental Regulation (1976a,b), the Tampa Bay Regional Planning Council (1977a,b), and the U.S. Environmental Protection Agency (1977a).

Table 2.3. Point-Source Discharges (Page 1 of 4)

					Loading in Discharge (lb/day)					
Location No.	Type*	Discharger	Design Capacity (mgd)	Average Daily Flow (mgd)	BOD$_5$	Suspended Solids	Total Nitrogen	Total Phosphorus	Ultimate Oxygen Demand	Primary Receiving waters
1	D	Double Branch Ranch	0.0043	0.004	0.98	0.7	0.7	0.20	4.3	Double Branch Creek
2	D	Hills County-River Oaks	3.0	0.975	68.3	28.5	24.4	8.1	143.6	Channel A to Old Tampa Bay
3	D	Hills County-Sweetwater #2	0.41	0.75	75.1	76.3	125.1	37.5	668.3	Rocky Creek
4	D	Hillsborough Trailer Park	0.0075	0.013	2.1	7.9	2.2	0.7	12.9	Ditch to Channel A
5	D	Barrington S/D	Not discharging							
6	I	Bear Plaza Koin Kleen Laundry	0.005	–	Laundry wastewater overflow during excessive rainfall					Lake with no outfall
7	D	Carrollwood S/D	0.453	0.463	44.4	64.5	77.2	23.2	410.1	Pol. pond to Sweetwater Creek
8	I	Honeywell, Inc.	0.57	0.38	Cooling water discharge					Barrow Pit to canal to Sweetwater Creek
9	D	Honeywell #1	0.1	0.025	23.0	2.4	–	1.3	22.0	Pond to Sweetwater Creek
10	D	Steak & Ale	0.01	0.003	0.1	0.1	0.1	<0.1	0.2	Sweetwater Creek
11	I	U.S. Army Reserve Center	Discharge during excessive rainfall only							Tampa storm sewers
12	D	Standard Sales	0.003	0.002	0.1	<0.1	0.1	<0.1	0.2	Drainage ditch to Sweetwater Creek
13	D	Major League Bowling	0.01	0.003	0.3	0.2	0.1	0.1	0.6	Barrow Pit to Sweetwater Creek
14	D	Pinecrest Utilities	0.525	0.512	237.3	225.0	85.4	25.6	696.4	Canal to Sweetwater Creek
15	D	Tampa Sub. Util.	0.75	0.64	54.5	104.6	106.8	32.0	557.9	Sweetwater Creek
16	D	Sweetwater Utilities #1	0.64	0.795	69.5	101.4	132.6	39.8	721.2	Sweetwater Creek
17	I	National Papaya	–	0.001	Bottle wash water					Drainage ditch to Old Tampa Bay
18	D	Egypt Shrine Temple	0.003	–	No data available					Old Tampa Bay
19	I	Gulf Gold (Seabrook Foods, Inc.)	–	0.1	260.0	111.3	30.14	–	–	Hillsborough Bay
20	I	Covington Development Corp. (Lake Padgett Pines)	–	–	1952.0	–	600.0	300.0	–	Cypress swamp to Hillsborough River
21	I	Shell Oil Company	Intermittent stormwater discharge							Tampa Bay
22	D	City of Tampa-Juanita Apts.	0.01	0.0035	0.1	0.2	0.6	0.2	2.8	Tampa Bay
23	D	Tampa Yacht Club	0.006	0.005	0.8	0.8	0.8	0.3	4.8	Hillsborough Bay
24	I	C.F. Industries	–	–	–	264.0	61.0	90.0	–	Hillsborough River
25	I	Florida Sip, Inc.	3.71	2.01	BOD$_5$ = 20 mg/ℓ		–	–	–	Ditch to Hillsborough River
26	D	Plant City	8.0	2.6	65.1	60.7	39.5	5.4	232.4	Mill Creek to Hillsborough River
27	I	Salada Foods, Inc.	No data available							Mill Creek to Hillsborough River
28	I	Lykes Bros., Inc.	0.315	0.345	154.6	243.4	–	–	–	Turkey Creek to Alafia River
29	I	Edgar Plastic Koalin Co.	3.5	2.5	Liquid waste to settling pond					Sparkman branch to Lake Thonotosassa
30	I	Treasure Isle Inc. (Ocean Products)	0.75	–	31.2	37.6	84.7	109.9	–	Onsite lake to Hillsborough River
31	D	City of Tampa-National Gypsum	0.0075	0.0024	0.1	0.1	0.4	0.1	2.8	Tampa Bay
32	I	Anheuser Busch	Cooling water is recycled and discharged with stormwater							Ditch to Hillsborough River
33	I	Winn Dixie Stores, Inc.	NPDES. Average daily temperature = 95°F							Hillsborough River
36	I	Millard's Laundry	0.004	0.003	0.98	2.05	–	–	–	Alafia River to Tampa Bay
37	I	Del Monte Corp.	0.08	–	NPDES: Average daily temperature = 95°F					City drainage to McKay Bay
38	I	American Can Co.	Cooling water discharge							Storm drain to Sparkman Channel
39	I	Tampa Municipal Incinerator	5.0	3.4	40.4	93.8	–	–	–	McKay Bay
40	I	Tampa Electric (Hookers Point Station)	–	513	–		–	–	–	Sparkman Channel
		Discharge #1	–	–	–	720.0	–	–	–	Sparkman Channel
		Discharge #2	–	–	–	50.0	–	–	–	Sparkman Channel
		Discharge #3	–	–	–	120.0	–	–	–	Sparkman Channel
		Discharge #4	–	–	–	–	–	–	–	Sparkman Channel
41	I	Cities Service Oil Company	NPDES: Average daily oil and grease = 10 mg/ℓ							Drainage ditch to Hillsborough Bay
42	I	Superior Seafoods, Inc.	Shrimp processing							Hillsborough Bay
43	I	Texaco, Inc.	NPDES: Daily maximum oil and grease = 10 mg/ℓ							Sparkman Channel
44	I	American Oil Co. (terminal)	0.10	–	NPDES: Average daily oil and grease = 10 mg/ℓ; pH = 6.0-8.5					Sparkman Channel
45	I	Union Oil Company	NPDES: Daily maximum oil and grease = 10 mg/ℓ							Hillsborough Bay

*D = Domestic
I = Industrial

Table 2.3. (Page 2 of 4)

Location No.	Type	Discharger	Design Capacity (mgd)	Average Daily Flow (mgd)	Loading in Discharge (lb/day)					Primary Receiving Waters
					BOD_5	Suspended Solids	Total Nitrogen	Total Phosphorus	Ultimate Oxygen Demand	
46	I	Sulphur Terminals Co., Inc.	Boiler blowdown, noncontact cooling water, waste condensate, and treated domestic wastewater							Sparkman Channel
47	I	American Petrofina Co. of Texas	NPDES: Average daily oil and grease = 10 mg/ℓ							Ditch to Sparkman Channel
48	I	Murphy Oil Co.	NPDES: Average daily oil and grease = 10 mg/ℓ							Hillsborough Bay
49	I	S.T. Triangali Co.	Shrimp processing wastewater							Hillsborough Bay
50	I	General Portland, Inc.	Air compressor cooling water. 137 mg/ℓ							Ybor Channel
51	D	City of Tampa-Hookers Point	36.0	41.0	53684.6	2[illegible]593.9	9437.5	2427.8	109552.4	Hillsborough Bay
52	I	Ralston Purina	Boiler blowdown							McKay Bay
53	I	Davies Can Company	NPDES: Daily average temperature = 95°F							Ditch to McKay Bay
54	I	Seaboard Coastline	0.325	–	Oil skimmer waste discharged during excessive rainfall					Creek to McKay Bay
55	D	East Lake Park	0.25	0.28	11.9	21.7	46.7	14	228.8	EPP to Palm River
56	D	Williams U.S. 301 Truck Stop	0.0125	0.004	0.4	0.3		0.2	3.6	Pol. pond to McKay Bay
57	I	M&T Chemicals, Inc.	–	0.001	0.6	Contaminants: iron, cyanide copper, lead, zinc				Ditch to McKay Bay
58	D	Adamo Acres	0.272	0.09	45.9	31.3	15.0	4.5	127.7	Canal to Palm River
59	D	Hazard MHP	0.0035	0.003	0.70	0.57	0.5	0.2	3.2	McKay Bay
60	I	Tampa Electric Co.(Gannon Sta.)	–	1279.7	Once-through cooling water, low volume waste sources, metal cleaning waste boiler blowdown, ash pond overflows, material storage, and construction runoff					Hillsborough Bay
61	I	W.R. Grace & Co.	–	1.44	Average winter temperature = 76°F, summer = 81°F					Hillsborough Bay
62	I	International Minerals & Chemical Company (IMC)	Cooling water discharge							Hillsborough Bay
63	D	TECO - Gannon	0.0045	0.003	0.4	0.51	0.5	0.2	2.9	Hillsborough Bay
64	I	Kaiser Agricultural Chem. Co.	–	0.04	–	11.5	211.0	–	–	Delaney Creek
65	I	Redwing Carriers, Inc.	0.01	–	30.0	Suspended solids = 30 mg/ℓ, BOD_5 = 30 mg/ℓ				Creek to McKay Bay
66	I	Compoamar Modern Dairies	Dairy process water; infrequent discharge							Delaney Creek to Hillsborough Bay
67	I	Nitram Chemicals, Inc.	–	0.44	–	–	395	–	–	Delaney Creek
68	I	Ideal Cement Co.	NPDES: Average daily temperature = 95°F							Hillsborough Bay
69	D	Progress Village	0.25	0.25	213.7	146.6	41.7	12.5	465.6	Canal to Hillsborough Bay
70a	D	Gardinier, Inc.	0.012	0.006	0.12	0.165	1.0	0.3	4.7	Alafia River
70b	I	Gardinier, Inc.	55.4	33.8	–	3849.0	416.0	1215.0		Alafia River
71	D	City of Mulberry MTP	0.500	0.200	11.0 ppm	17.0 ppm	–	–	264.0	North prong of Alafia River
72	I	Borden, Inc.	No discharge has occurred in past several years							English Creek to north prong of Alafia River
73b	I	W.R. Grace & Co.	20.2	4.32	–	778.0	99.0	19.0	–	Alafia River
73a	I	W.R. Grace & Co.	1.44	1.44	–	272.0	41.0	83.0	–	Alafia River
73b	I	W.R. Grace & Co.	–	5.76	–	382.0	137.0	97.0	–	Peace River
74	I	Borden, Inc.	–	1.300	–	–	–	–	–	Pole, Creek to north prong of Alafia River to Alafia River to Tampa Bay
75	I	Royster Co.	1.000	0.640	–	131.0	20.0	16.0	–	Alafia River
76	I	Mobil Chemical Co.	–	0.440	–	84.0	1.0	2.0	–	Alafia River
77	I	Farmland Industries	–	5.600	–	1110.0	9478.0	127.0	–	Alafia River
78	I	C.F. Chemicals, Inc.	–	8.400	–	1214.0	191.0	517.0	–	Alafia River
79	I	Spring Valley Dairies, Inc.	–	–	NPDES:	Effective June 30, 1976, retain all process wastewaters plus 5 inches of rainfall from 24-hour incident				Bell Creek to Alafia River
80	I	T.A. Minerals	No discharge							
81	I	Agrico Chemical Co.	No discharge							
82	I	Swift Agricultural Chemicals	–	5.6	–	258.0	17.0	25.0	–	North prong, Alafia River Alafia River
	I	Swift Agricultural Chemicals	–	3.1	–	791.0	6.0	106.0	–	Peace River

Table 2.3. (Page 3 of 4)

Location No.	Type	Discharger	Design Capacity (mgd)	Average Daily Flow (mgd)	Loading in Discharge (lb/day)					Primary Receiving Waters
					BOD_5	Suspended Solids	Total Nitrogen	Total Phosphorus	Ultimate Oxygen Demand	
83	I	IMC	11.200	1.300	–	174.0	3.0	3.0	–	Peace River
84	I	Agrico Chemical Co.	No discharge							
85	I	Conserv Inc.	1.000	–	–	255.0	47.0	56.0	–	Alafia River
86a	I	IMC	–	2.7	–	351.0	14.0	14.0	–	Hooker's Prairie to south prong, Alafia River
86b-c	I	IMC	–	5.3	–	755.0	27.0	13.0	–	South prong, Alafia River
87	I	Brewster Phosphates	0.010	0.010	20.0	20.0	Insignificant data			South prong, Alafia River
89	I	Borden, Inc. (Chemical Div.)	Contaminated rainwater (80 mg/ℓ) discharged from setting pond during > 10-year 24-hour chronic rainfall event if waste setting pond is full							South prong, Alafia River
90	I	Brewster Phosphates	–	–	–	–	–	–	–	Emergency discharge to ditch to Alafia River
91	I	Florida Agglite	–	3.7	Average total suspended solids = 28 m/ℓ; total phosphate = 2.8 mg/ℓ					Ditches to Alafia River
92	I	Rawlins Fish Farm	–	–	Fish culturing ponds overflow					Ditch to Alafia River
93	I	Gibsonton Speed Wash	0.02	–	Trickling filter wastewater					Ditch to Alafia River
94	D	Nistal TP	Not discharging							
95	D	Alafia MHP	0.02	0.0065	0.39	0.36	1.1	0.3	5.5	Bullfrog Creek to Tampa Bay
96	D	Eastwood Est. MHP	0.03	0.007	0.3	0.4	1.2	0.4	5.7	Bullfrog Creek
97	I	Ruskin Tomato Growers, Inc.	NPDES: Average daily chlorine residual = 1.0 mg/ℓ							Newman Branch Creek to Tampa Bay
98	D	TECO – Big Bend	0.0045	0.003	0.31	0.4	0.5	0.15	2.7	Tampa Bay
99	I	Tampa Electric (Big Bend Sta.)	–	1036	Treated boiler blowdown and untreated stormwater runoff					Canal to Tampa Bay
100	I	Ruskin Veg. Corp.	NPDES: Average daily chlorine residual = 1.0 mg/ℓ							Ditch to Tampa Bay
101	D	Apollo Beach	0.5	0.318	29.7	14.0	53.0	15.9	280.6	Drainage canal to Tampa Bay
102	D	Bahia Beach	Not discharging							
	D	Coffee Cup Restaurant	0.003	0.021	0.35	0.55	0.2	<0.1	1.2	Ruskin inlet to Little Manatee River
103	I	Shirley Ann's Laundry	–	0.0055	Trickling filter effluent					Ruskin inlet to Little Manatee River
104	I	Ruskin Laundryland	0.01	0.009	2.9	Trickling filter effluent				Ruskin inlet to Little Manatee River
105	D	Sun City	Not discharging							
106	I	Tidwell Fish Farm #2	Fish culturing process discharge							Ditch to Little Manatee River
107	I	Tidwell Fish Farm #1	Fish culturing process discharge							Ditch to Little Manatee River
108	I	Proctor & Sons Fish Farm	Fish culturing pond overflow							Ditch to Tampa Bay
109	I	Florida Power & Light	Cooling water reservoir overflow during high rainfall							Little Manatee River
	I	Florida Power & Light	–	1.1	Cooling water discharge					Little Manatee River
	I	Florida Power & Light	–	0.18	Cooling water discharge plus plant stormwater runoff					Gamble Creek
110	I	Ross Socolof Farms Inc.	Fish farm wastewater							Frog Creek to Terra Ceia Bay
111	I	Ross Socolof Farms Inc.	Fish farm wastewater							Frog Creek to Terra Ceia Bay
112	I	Borden, Inc.	1.98	–	117.0	43.0	44.0	–	–	Alafia River
113	D	Coach House MHP	0.08	0.033	2.3	3.4	5.5	1.7	28.2	Canal to Terra Ceia Bay
114	I	Gordon's Siffy Clean	No data available							Terra Ceia Bay
115	D	Tillman Elem.	0.01	0.002	0.2	0.2	0.3	0.1	1.8	Manatee River
116	D	Palm Grove MP	0.012	0.004	0.5	0.3	0.7	0.2	3.7	Canal to Manatee River
117	D	Blackburn Elem.	0.05	0.003	0.2	0.1	0.5	0.2	2.6	Manatee River
118	D	Tideview Estates	0.1	0.04	2.8	2.3	6.7	2	34.1	Canal to Manatee River
119	D	Stills Motel	0.003	0.001	<0.1	0.1	0.2	0.1	0.8	Creek to Manatee River
120	D	Leisure Lakes TP	0.035	0.015	3.1	4.8	2.5	0.8	15.4	Canal to Terra Ceia Bay
121	D	Palmetto	1.4	0.68	74.3	94.7	113.4	34.0	614.0	Pol. pond to Terra Ceia Bay
122	I	Tropicana	–	2.6	2280.0	–	–	–	–	Manatee River
123	D	Bradenton	6.0	2.6	86.7	130.0	433.7	130.1	2093.5	Manatee River
124	D	Golf Lakes MHE #2	0.05	0.05	20.1	30.1	8.3	2.5	64.0	Ditch to Manatee River
125	D	Golf Lakes MHE #1	0.05	0.05	23.8	24.5	8.3	2.5	68.7	Ditch to Manatee River
126	D	Floridana Utilities	0.033	0.033	1.5	3.0	0.6	1.7	27.0	Cedar hammock to Manatee River
127	D	Oneco Elem.	0.006	0.004	0.2	<0.1	0.7	0.2	3.3	Ditch to Sarasota Bay
128	I	Yee Oldee Wash Tub	–	–	Trickling filter effluent during periods of ex-excessive rainfall					Ditch to Bowlee's Creek
129	D	Luxor TP	0.01	0.004	0.5	0.6	0.7	0.2	3.7	Storm drain to Manatee River
130	D	Cortez Estates	0.091	0.017	0.4	0.2	2.8	0.9	13.5	Palma Sola Creek
131	D	Villa del Sol	0.02	0.014	0.6	0.6	2.3	0.7	11.4	Oneco drain to Bowlee's Creek
132	I	Becker Phosphate Corp. (not in operation)	Treated phosphate waste discharged with excess stormwater							Wingate Creek

Table 2.3. (Page 4 of 4)

Location No.	Type	Discharger	Design Capacity (mgd)	Average Daily Flow (mgd)	Loading in Discharge (lb/day)					Primary Receiving Waters
					BOD_5	Suspended Solids	Total Nitrogen	Total Phosphorus	Ultimate Oxygen Demand	
133	I	Borden	–	–	–	97.0	3.0	4.0	–	Peace River
134	D	Padgett Elem. School	0.012	–	–	–	–	–	–	Bayhead and Lake Gibson
135	D	Lake Gibson Estates	0.060	–	–	–	–	–	–	Lake Gibson
136	D	City of Lakeland Pt. #3	262.400	262.400	–	–	–	–	–	Lake Parker to Peace River
137	D	City of Lake Alfred	0.300	0.176	13.6	10.2	–	–	232.0	Polishing pond to Lake Haines
138	D	Lakeside Ranch MHP	0.020	–	1.55	2.64	–	–	–	Lake Henry
139	I	Sun-Citrus Products	0.200	–	–	–	–	–	–	Lake Tracy to Peace River
140	D	Sunset Mobile Manor	0.010	–	–	–	–	–	–	Lake Mariana to Peace River
141	D	Boards Trailer Park	0.016	–	–	–	–	–	–	Lake Jessie
142	D	City of Winter Haven #2	1.700	0.920	34.6	73.1	–	–	1214.0	Polishing pond to Lake Conine
143	I	Coca Cola Co. Foods	7.000	3.000	–	–	–	–	–	Lake Lena Run to Peace River
144	D	City of Auburndale	1.230	0.500	–	–	–	–	660.0	Lake Lena Run
145	I	Jacquin Florida Dist. Co.	0.025	0.238	–	–	–	–	–	Lake Lena Run to Peace River
146	D	Lake Blue MHP	0.015	–	–	–	–	–	–	Drainage ditch to Lake Jessie
147	I	Birds Eye Div., General Foods	0.500	2.000	Cooling water only					Lake Conine
148	I	Birds Eye Div., General Foods	2.200	2.000	–	–	–	–	–	Lake Conine to Peace River
149	D	Lucerne Park Mobile	0.015	–	–	–	–	–	–	Pond to Peace River
150	D	City of Winter Haven #1	3.300	1.660	141.0	521.0	–	–	2191.0	Lake Lulu
151	I	Bordo Citrus Products Co.	0.750	1.000	–	–	–	–	–	Lagoons to Peace Creek canal
152	D	Florida Cypress Gardens	0.0025	–	–	–	–	–	–	
153	D	Garden Grove Pines	0.1138	0.069	3.4	13.5	–	–	91.0	Polishing pond to Peace River
154	D	City of Bartow	0.200	0.060	15.8	4.37	–	–	66.0	Cashin swamp to Wanneta Canal
155	D	Orange Manor MHP	0.015	–	–	–	–	–	–	Lake Eloise to Peace River
156	I	Florida Tile Inc.	0.010	0.010	–	–	–	–	–	Settling pond to Lake Wire
157	I	Juice Bowl Products	0.307	0.006	–	–	–	–	–	Banana Lake to Peace River
158	I	A-I Products Inc.	0.160	0.144	–	–	–	–	–	Ditch to Banana Lake
159	D	City of Lakeland	10.000	9.100	770.0	77.0	–	–	12012.0	Banana Lake
160	I	Grower Process, Inc.	0.280	–	–	–	–	–	–	Banana Creek to Peace River
161	I	Citrus World Inc.	2.000	1.300	–	–	–	–	–	Lake Effie to Peace River
162	D	City of Lake Wales	1.000	0.840	165.1	250.5	–	–	1109.0	Lake Effie
163	I	USS Agrichem	4.0	4.0	–	690.0	195.0	1112.0	–	Bear Branch to Peace River
164	D	City of Bartow	2.750	1.450	267.0	631.0	–	–	1914.0	Peace River
165	I	Ben Hill Griffin Inc.	3.0	0.230	–	–	–	–	–	Peace River
166	I	IMC	14.71	10.50	–	925.0	182.0	85.0	–	Peace River
167	I	Mobil Chem. Co.	0.412	0.9	–	8280.0	15,210.0	180.0	–	Peace River
168	I	Sun Coast Fruit Co.	0.200	0.200	–	–	–	–	–	Ditch to Peace River
169	D	City of Ft. Meade	0.530	0.400	28.0	145.0	–	–	528.0	Peace River
170	I	Swift	–	7.4	–	901.0	9.0	48.0	–	Peace River
171	I	USS Agrichem	–	2.500	–	720.0	4.0	207.0	–	Peace River
172	I	Agrico Chemical Co.	–	–	–	192.0	12.0	12.0	–	Peace River
173	I	Agrico Chemical Co.	No discharge							Whidden Creek to Peace River
174	I	Gardinier	–	8.7	–	1961.0	42.0	72.0	–	Peace River
175	I	USS Agrichem	25.8	–	–	5418.0 -	627.0	1966.0	–	Mill branch to Peace River
176	I	Agrico Chemical Co.	5.760	5.760	–	534.0	23.0	35.0	–	Saddle Creek to Peace River
177	I	Agrico Chemical Co.	–	6.8	–	364.0	47.0	62.0	–	Peace River
178	I	Agrico Chemical Co.	–	14.8	–	1380.0	145.0	163.0	–	Peace River
179	D	Bowling Green	0.200	0.090	8.34	217.0	–	–	119.0	Polishing pond to Peace River
180	I	Cities Service Inc.	–	1.300	Phosphate mine waste					Whidden Creek to Peace River
181	I	Peace River Proc. Inc.	2.500	2.230	–	–	–	–	–	City sewer to Peace River
182	D	City of Wauchula	1.000	0.530	135.0	179.0	–	–	700.0	Ditch to Peace River
183	D	City of Arcadia	1.000	0.700	–	–	–	–	1320.0	Joshua Creek to Peace River
184	D	Road Prison #11	0.004	0.0038	–	–	–	–	5.3	Pond to Peace River
185	D	Mary Lu Trailer Park	0.018	0.004	0.05	0.23	–	–	23.0	Polishing pond to Peace River
186	D	River Forest MHP	0.015	0.009	0.47	7.8	–	–	19.8	Peace River
187	D	Palm & Pines Trailer Park	0.015	0.015	–	–	–	–	19.8	Peace River
188	D	General Development Util.	1.500	1.131	0.38	0.90	–	–	1980.0	Olean waterway to Charlotte Harbor
189	D	Harbor Inn Motel	0.008	0.002	–	–	–	–	10.5	Peace River
190	D	Palmetto MHP	0.013	0.006	–	–	–	–	17	Charlotte Harbor
191	D	Deep Creek Utilities	0.042	0.042	–	–	–	–	55	DeSoto Canal to Peace River
192	D	City of Punta Gorda	1.300	0.434	13.3	18.5	–	–	1320	Peace River
193	D	Parkhill Manor #2	0.015	0.015	0.34	0.35	–	–	19.8	Alligator Creek
194	D	Pine Terrace Trailer Park	0.015	–	–	–	–	–	19.6	Pond to Charlotte Harbor
195	D	Parkhill Manor #1	0.015	0.013	1.1	1.3	–	–	19.8	Alligator Creek
196	D	Gasparilla Mobile Est.	0.015	–	–	–	–	–	19.8	Canal to Gasparilla Sound

The municipal and industrial discharges occur in two distinct linear north-south patterns coinciding closely with the population distribution and industrial development within the area. Hillsborough and Polk counties exhibit the largest amount of industrial discharge due largely to effluent from the phosphate mining and processing industry. Wastewater discharge of 0.5 million gallons per day or more by county and the discharge categories are as follows (U.S. Army Corps of Engineers 1977):

County	Municipal (mgd)	Industrial (mgd)	Total (mgd)
Charlotte	2.0	-	2.0
DeSoto	0.8	-	0.8
Hardee	0.7	2.2	2.9
Hillsborough	46.2	77.3	123.5
Manatee	13.0	-	13.0
Polk	13.4	151.1	164.5
Sarasota	10.3	-	10.3
Total	86.4	230.6	317.0

a. Tampa/Hillsborough Bay System

The Tampa/Hillsborough Bay system is composed of adjoining bays and estuaries that include Boca Ciega Bay, Tampa Bay, Old Tampa Bay, Hillsborough Bay, McKay Bay, and Terra Ceia Bay.

Hillsborough Bay is bounded on the west and north by the Tampa metropolitan area. Hooker's Point, a natural peninsula extending into Hillsborough Bay, is the site of most of Tampa's heavy industry and port terminals. At privately financed Port Sutton on the northeastern edge of Hillsborough Bay are sulfur, scrap iron, and phosphate terminal facilities as well as Tampa's largest steam electric-generating plant. South of Port Sutton, the eastern shore of Hillsborough Bay is largely undeveloped except for Gardinier Inc., a phosphate products plant at the mouth of the Alafia River.

A picture of the severity of water quality problems within the Tampa Bay region (Figure 2.3) emerges from a draft report from the Tampa Bay Regional Planning Council (1977b). The report concluded that:

- Major nonpoint-source water quality problems within the Tampa Bay region are due primarily to urban runoff rather than to agricultural runoff
- Excessive concentrations of nitrogen and phosphorus, one of the region's most widespread problems, have led to eutrophic conditions in some lakes and poorly circulated bays
- Bacteria from sewage and livestock wastes is a chronic health hazard in many water bodies, frequently causing the closing of swimming and shellfish-harvesting areas
- Low dissolved oxygen from sewage and livestock wastes and from organic discharges of industrial origin is a chronic problem in many areas

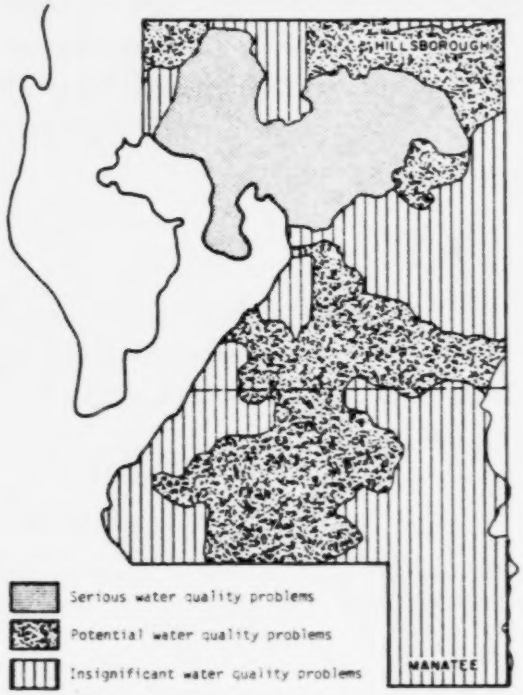
HILLSBOROUGH
MANATEE
Serious water quality problems
Potential water quality problems
Insignificant water quality problems

Figure 2.3. Generalized Severity of Water Quality Problems within Tampa Bay Area (Tampa Bay Regional Planning Council 1977b)

Storm-sewer outfalls 60 inches or more in diameter discharge from the city of Tampa to Hillsborough Bay, to Old Tampa Bay, and to McKay Bay. The city's Hooker's Point sewage-treatment plant provides primary treatment only to 41 million gallons per day of municipal wastewater producing an effluent containing 150 milligrams per liter of biochemical oxygen demand and 70 milligrams per liter of suspended solids. This discharge produces a major drain on the oxygen resources of Hillsborough Bay (Tampa Bay Regional Planning Council 1977c).

Upper Hillsborough Bay is characterized by some of the poorest water quality in the Tampa Bay system. In comparing Hillsborough Bay (TB.1) with the other segments of the Tampa Bay system (TB.2 and TB.3) from the data on Plate 4, Hillsborough Bay is observed to be higher in color, fluoride, nitrate-N, ammonia-N, organic-N, ortho- and total phosphorus, turbidity, total organic carbon, hardness, and coliform bacteria and lower in dissolved oxygen and pH than either Old Tampa Bay or Tampa Bay proper. However, according to Hillsborough County data (Shaw 1975), there have been improvements since 1972 (decreases in turbidity and coliforms and increased dissolved oxygen).

Wastewater input to Hillsborough Bay was investigated in 1969 to determine the causes of obnoxious odors along its western shore (FWPCA 1969). The resulting data appear in Table 2.4.

Table 2.4. Effluent Waste Loads to Hillsborough Bay†

		Mass Unit (lb/day) and Percentage of Total Waste Input to Hillsborough Bay														
Point Source	Flow	5-Day BOD	%	Ultimate BOD	%	Total Suspended Solids	%	Ammonia Nitrogen	%	Nitrate/ Nitrite	%	Total Kjeldahl Nitrogen	%	Total Phosphate	%	pH
Tampa Sewage Treatment Plant	27.8 mgd	49,000	85.4	66,000	84.5	25,900	35.4	6,200	41.7	-	-	7,300	43.1	2,700	4.8	6.9
Gardnier Inc., Gibsonton	-	-	-	-	-	14,940	20.5	2,080	14.0	-	-	2,080	12.3	8,810	15.8	-
Nitram Chemical Co.*	-	-	-	-	-	-	-	2,880	19.4	-	-	2,880	17.0	-	-	8.3
Alafia River*	292 cfs	3,960	6.9	-	-	16,760	22.9	3,280	22.1	3,590	-	3,450	20.4	43,470	78.0	6.2
Hillsborough River**	257 cfs	3,300	6.9	-	-	11,470	15.7	210	1.4	40	-	910	5.4	630	1.1	7.6

†FWPCA (1969).

*Through a lagoon to Delaney Creek.

**Measured at Lithia, Florida

***Measured above water supply reservoir dam.

Summarizing the results of the FWPCA study, the Tampa sewage-treatment plant was the single greatest contributor of 5-day BOD (representing a major drain on the oxygen resources of the bay), total dissolved solids, ammonia nitrogen, and total Kjeldahl nitrogen. High coliform densities (106,000-107,000 per 100 milliliters) were found near the Tampa sewage-treatment plant outfall and were confined to Hillsborough Bay. The Alafia River was the single largest contributor of total phosphate.

Also in the Tampa/Hillsborough Bay system, McKay Bay exhibits poorer water quality than do the open areas of Tampa Bay (Tampa Bay Regional Planning Council 1977c). Normally in McKay Bay, for example, dissolved oxygen reaches supersaturation at the surface but remains below 4 milligrams per liter at the bottom; BOD averages a moderate 4 milligrams per liter and ranges from 2 to 6 milligrams per liter, which is of greater concern in a poorly flushed restricted bay than in a flowing stream; chlorophyll-a concentrations are high; and phosphate concentrations average more than twice that of open Tampa Bay levels. These high levels of chlorophyll, nutrients, and BOD could produce acutely low oxygen during the night in parts of the bay.

The Tampa/Hillsborough Bay characterization in Table 2.5 is based on data obtained from the Department of Environmental Regulation (1976a).

Table 2.5. Chemical Characterization for Tampa/Hillsborough Bay†

	Total Nitrogen (mg/l)	Organic Nitrogen (mg/l)	Ammonia (mg/l)	Phosphate (mg/l)	Fecal Coliform (per 100 ml)	Phyto. Biomass (mg/m^3)	Dissolved Oxygen (mg/l)
Hillsborough Bay (TB.1)							
Average	1.32	0.88	0.32	1.99	308	37.9	5.7*
Period	1974-75	1972-75	1972-75	1972-75	1974-75	1972-75	1972-75
Old Tampa Bay (TB.2)							
Average	0.81	0.77	-	1.25	-	-	5.7**
Period	1973-75	1971-75		1972-74			1972-74
Lower Tampa Bay (TB.3)							
Average	0.60	-	-	1.22	335	-	7.1***
Period	1973-75			1971-75	1972-75		1972-75

†Florida Department of Environmental Regulation (1976).

*With minimum of 0.6 mg/l.

**With minimum of 2.8 mg/l.

***With minimum of 4.9 mg/l.

The data for 1970-76 presented on Plate 4 shows the same general trends as those seen in Table 2.5: highest coliform concentrations were found in TB.1, with TB.2 and TB.3 exhibiting lower concentrations; and organic nitrogen, nitrate, ammonia, fluoride, color, turbidity, and TOC concentrations decreased from TB.1 to TB.2 to TB.3 respectively.

Shaw (1975), in a study of the water quality in Hillsborough County in 1975, found that:

- The highest phosphate concentrations in the Tampa Bay system were in the eastern portion of Hillsborough Bay in the vicinity of the Alafia River near the Gardinier Inc. plant.
- Nitrogen concentrations in Hillsborough Bay and Old Tampa Bay were highest in areas receiving primary and secondary sewage effluents.
- Excessive nutrient concentrations and associated problems will continue in the Tampa Bay Basin until the phosphate industries in Hillsborough and Polk counties reduce their phosphate discharge and the sewage-treatment plants surrounding the basin provide advanced waste treatment.
- Unacceptably high bacterial concentrations will continue in Hillsborough Bay and the northeast portion of Old Tampa Bay until advanced waste-treatment plants replace the Hooker's Point treatment plant and existing secondary sewage-treatment plants.
- Highest fluoride concentrations (10.4 milligrams per liter) occurred near the mouth of the Alafia River, primarily because of the industrial discharge of the Gardinier plant; averages were more than 2.5 milligrams per liter in the eastern portion of Hillsborough Bay, between 2.0 and 2.5 milligrams per liter in the remainder of Hillsborough Bay, and between 1.0 and 1.5 milligrams per liter in Old Tampa Bay and upper Tampa Bay.
- The low pH value (4.4) at the mouth of the Alafia River was attributed to the sulfuric and phosphoric acid effluents from the Gardinier plant.

Nonpoint sources of pollution are a function of particular groups of land use; e.g., agricultural land use activities result in runoff containing pesticides, fertilizer, and animal wastes, whereas commercial activities contribute heavy metals, grease, and oil. Therefore, the characterization and quantification of nonpoint loads is a function of land use. In the Tampa Bay area, there has been intense development along the extensive waterfront; in other areas inland, development has taken place near activity centers such as Tampa and Plant City and along transportation corridors (more fully discussed in Volume III of this series of working papers). This development has involved a mixture of land uses, ranging from agricultural, industrial, residential, and institutional in some areas to sprawling residential subdivisions and extensive strip commerical development in others (Tampa Bay Regional Planning Council 1977b). As a result, the nonpoint pollution wasteloads are generally increasing, as verified by existing water quality data. However, some exceptions to this trend have been found in the Tampa Bay region; in areas where cropland and pasture contribute high loadings (especially nutrient loadings), the development of these lands may decrease the pollutant load.

Projecting to the year 2000, the most significant point-source trend in the Tampa Bay area will be the reduction in the number of point sources: most will be consolidated into existing or projected wastewater treatment plants or will become nondischargers as a result of using alternate methods of effluent disposal (mainly spray irrigation and deep well injection).

Figure 2.4 summarizes the projected water quality problems for the Tampa Bay region to the year 2000 assuming that "208" plans (water quality management plans required by section 208 of the Federal Water Pollution Control Act of 1972) are not implemented. The most serious water quality problems for the Tampa Bay region will continue to be around the Tampa urban area. All of the coastal area will experience moderate to severe water quality degradation as coastal development continues. Only the easternmost portions of the Tampa Bay planning area (that within the study area shown in Figure 2.4) will remain relatively unaffected. According to the Tampa Bay Regional Planning Council (1977b), the further intrusion of phosphate mining into eastern Hillsborough and Manatee counties could adversely affect the water quality of these areas.

b. Charlotte Harbor

Charlotte Harbor is the dominant surface-water feature of the southern half of the study area. The major tributaries to the harbor are

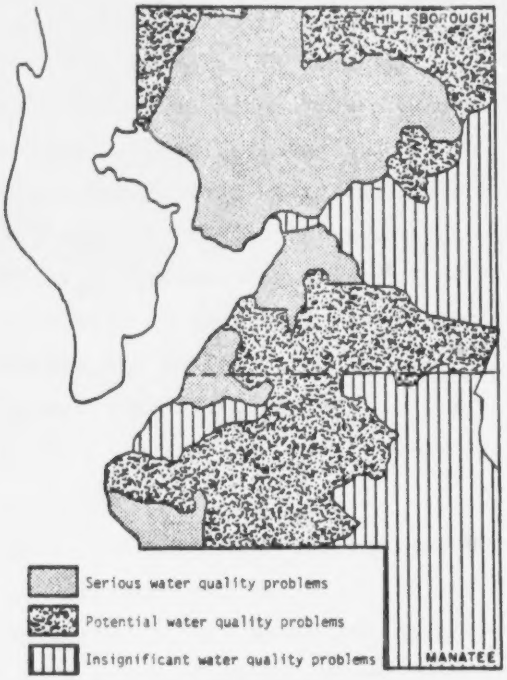
HILLSBOROUGH
Serious water quality problems
Potential water quality problems
Insignificant water quality problems
MANATEE

Figure 2.4. Generalized Anticipated Water Quality in Tampa Bay Region (Tampa Bay Regional Planning Council 1977b)

the Peace and Myakka rivers; the minor tributaries include North Fork, Alligator, Big Mound, Winegourd, and Yucca Pen creeks and Bear, Whidden, and Hog branches. The area surrounding Charlotte Harbor is typical of the southwestern Florida region; the surface is relatively flat along the limits of the floodplain, gradually rising to more inclined slopes farther inland.

Generally, most of the Charlotte Harbor area is sparsely populated but has received considerable development pressure in recent years. Punta Gorda and Port Charlotte along the northeast and north coastlines are the major urban developments.

The relatively few point sources of discharge to Charlotte Harbor are identified in Table 2.3, and their locations are indicated on Plate 1 (in pocket). One will note that there are no industrial point-source dischargers surrounding Charlotte Harbor; most of the land surrounding the harbor is used for agriculture or recreation, comprises marshes and floodlands, or is vacant.

Draft document material for the Southwest Florida Regional Planning Council (SWFRPC) "208" study has been helpful in describing present and projected contributions to the water quality of Charlotte Harbor. The SWFRPC reports that the northernmost segment of Charlotte Harbor, which receives discharge from the Peace and Myakka rivers, Punta Gorda, and Port Charlotte and runoff from the immediate area, presently receives and is predicted to receive through 1998 much greater phosphorus and nitrogen loading than any other segment of the harbor. Estimated loadings for the wet and dry seasons are shown in Table 2.6. The water quality data displayed on Plate 4 showed higher phosphorus and nitrogen concentrations in CH.1 and CH.2 than in CH.3, which is indicative of the greater loading to CH.1 and CH.2.

Table 2.6. Nitrogen and Phosphorus Loadings to Charlotte Harbor, Segment 1, by Season*

Year	Season	Total Nitrogen (lb)	Total Phosphorus (lb)
1976	Dry	1.08×10^6	9.42×10^5
	Wet	3.19×10^6	2.22×10^6
1978	Dry	2.92×10^6	3.88×10^6
	Wet	4.40×10^6	4.24×10^6
1983	Dry	2.92×10^6	3.93×10^6
	Wet	4.40×10^6	4.25×10^6
1988	Dry	2.92×10^6	3.88×10^6
	Wet	4.41×10^6	4.25×10^6
1993	Dry	2.93×10^6	3.88×10^6
	Wet	4.42×10^6	4.25×10^6
1998	Dry	2.93×10^6	3.89×10^6
	Wet	4.42×10^6	4.25×10^6

*Southwest Florida Regional Planning Council (1977)

The Peace River is the dominant contributor of nitrogen and phosphorus to Charlotte Harbor; ranking second, third, and fourth respectively are the Myakka River, runoff, and point sources. As can be seen in Table 2.6, total loads of both nitrogen and phosphorus are higher during the wet season than during the dry season. The SWFRPC, in conducting further analysis of nitrogen and phosphorus loadings to Charlotte Harbor, found that CH.1 and CH.2 (Plate 1) received the most loading. Since it was found that the increased discharges of the wet season contributed the most loading and August is historically the month of greatest river discharge, the SWFRPC did a detailed study of the northernmost segment of Charlotte Harbor during August. The expected loads to the segment by the various sources through 1998 are indicated in Table 2.7. The runoff designations of 1, 6, and 7 in the table are depicted in Figure 2.5.

Table 2.7. Predicted Loads of Nitrogen and Phosphorus by Principal Sources to Segment 1, August*

Year	Source	Total Nitrogen (lb)	Total Phosphorus (lb)
1976	Peace River	6.88×10^5	5.62×10^5
	Myakka River	1.44×10^5	3.70×10^4
	Runoff		
	1	1.49×10^4	4.54×10^3
	6	7.13×10^3	2.35×10^3
	7	3.71×10^4	1.26×10^4
	Point Source	1.67×10^3	1.76×10^2
1978	Peace River	1.47×10^6	1.54×10^6
	Myakka River	1.68×10^5	2.67×10^5
	Runoff		
	1	2.04×10^4	6.21×10^3
	6	9.62×10^3	3.18×10^3
	7	5.01×10^4	1.71×10^4
	Point Source	1.67×10^3	1.76×10^2
1983	Peace River	1.47×10^6	1.54×10^6
	Myakka River	1.68×10^5	2.67×10^5
	Runoff		
	1	2.09×10^4	6.36×10^3
	6	9.84×10^3	3.23×10^3
	7	5.02×10^4	1.71×10^4
	Point Source	1.67×10^3	1.76×10^2
1988	Peace River	1.47×10^6	1.54×10^6
	Myakka River	1.68×10^5	2.67×10^5
	Runoff		
	1	2.39×10^4	7.1×10^3
	6	1.03×10^4	3.35×10^3
	7	5.02×10^4	1.71×10^4
	Point Source	0	0
1993	Peace River	1.47×10^6	1.54×10^6
	Myakka River	1.63×10^5	2.67×10^5
	Runoff		
	1	2.54×10^4	7.47×10^3
	6	1.09×10^4	3.52×10^3
	7	5.02×10^4	1.71×10^4
	Point Source	0	0
1998	Peace River	1.47×10^6	1.54×10^6
	Myakka River	1.68×10^5	2.67×10^5
	Runoff		
	1	2.66×10^4	7.77×10^3
	6	1.17×10^4	3.75×10^3
	7	5.02×10^4	1.71×10^4
	Point Source	0	0

*Southwest Florida Regional Planning Council (1977).

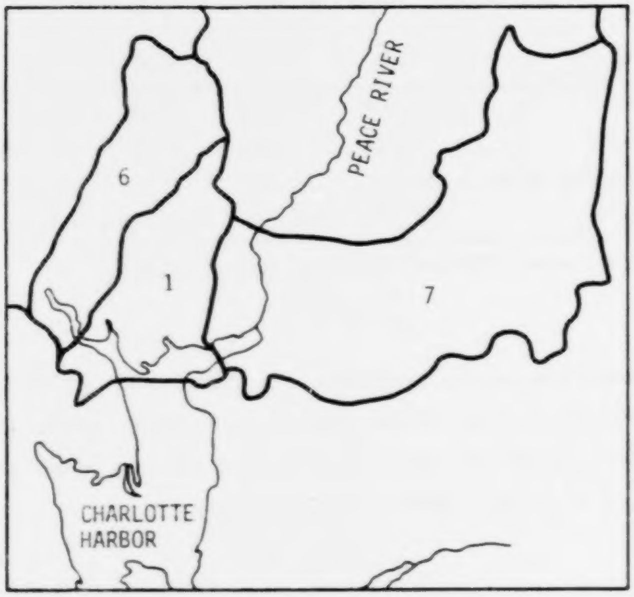

Figure 2.5. Segments Contributing to Northernmost Segment of Charlotte Harbor (Southwest Florida Regional Planning Council 1976)

The predicted increase in phosphorus and nitrogen loads from runoff and the Peace and Myakka rivers from 1976 to 1978 reflects the increased development on lands surrounding Charlotte Harbor (segment 1); i.e., more acres are being transformed into residential and commercial use at the expense of open and other urban and agricultural uses (Table 2.8). The data reflect the greater development expected within segments 1 and 6 than within segment 7. The point-source pollutant load will remain about the same from now until the year 1983, because all point sources to the Charlotte Harbor segment are domestic dischargers that must not exceed their 1976 pollutant loads through 1983. After 1985, all of the domestic wastewater sources should be using alternate methods of disposal and not discharging to surface waters; therefore, the point-source load of nitrogen and phosphorus into Charlotte Harbor is expected to drop to 0 after 1985.

Table 2.8. Predicted Acreage Draining to Segment 1 of Charlotte Harbor*

Land Use	1976	1978	1983	1988	1993	1998
Residential	16,039	16,308	18,320	24,837	29,084	33,581
Commercial	2,800	2,920	3,122	3,402	3,666	3,898
Open and other urban	40,021	39,802	38,217	33,481	31,090	27,841
Agricultural	431,876	431,794	432,200	429,107	426,987	425,509

*Southwest Florida Regional Planning Council (1977)

Referring again to Plate 4, CH.1 and CH2 display greater concentrations of color, nitrate, organic nitrogen, total phosphorus, and total coliform than does CH.3. Segment CH.1 is often closed to shellfish harvesting because of high coliform concentrations.

c. Hillsborough River

The Hillsborough River area was described in Section 1 of this volume. Land use along the northern portion of the river (H.1 and H.2) is approximately 76 percent agricultural, 11 percent marsh and swamp, and 8 percent forest. Land use surrounding the more southern portion of the river (H.3 and H.4) is approximately 50 percent agricultural, 30 percent urban, and 11 percent forest. Runoff from the agricultural land in segments H.1 and H.2 is indicated (see Plate 4) by fairly high nitrogen, total organic carbon, and total coliform concentrations. Orthophosphate concentrations (0.2-1.0 milligrams per liter) reported by the Southwest Florida Regional Planning Council (1976) are not outside the natural range expected for the area.

Receiving drainage from a large part of the area south of segments H.1 and H.2, including the Plant City urban area, is Lake Thonotosassa, which discharges to Flint Creek, which in turn flows a short distance to the Hillsborough River. Even with improved point-source controls, highly eutrophic Lake Thonotosassa is not expected to improve much becasue of continuing high inputs of nutrients, particularly nitrogen (Tampa Bay Regional Planning Council 1977c).

Tampa Reservoir, which is in segment H.3, is characterized (Tampa Bay Regional Planning Council 1977c) by high chlorophyll levels (up to 160 milligrams per cubic meter), widely fluctuating daytime oxygen (3-14 milligrams per liter), uniformly high phosphate (about 0.3 milligrams per liter), and frequently very high nitrate (up to 2 milligrams per liter). These values indicate highly eutrophic conditions.

Below the dam, the Hillsborough River is brackish and influenced by tidal variations. The lower mile is channelized; maintenance dredging has created a line of spoil islands and submerged banks, effecting a division of the bay that may restrict tidal and wind mixing. The dredging activity is evidenced by the extremely high turbidity values (Plate 4) for segment H.4. The U.S. Army Corps of Engineers estimates that the Hillsborough River discharges an average daily load of 950 pounds of nitrogen, 630 pounds of phosphate, and 3,300 pounds of BOD to the bay.

d. Alafia River

The Alafia River provides drainage for about 460 square miles. From its headwaters in Polk County among the heavy phosphate mining operations, it flows approximately 24 miles to its mouth at the southern end of Hillsborough Bay and discharges approximately 360 million gallons per day. The river may be divided into three main sections: the Alafia River proper (A.10-A.12), the North Prong (A.1-A.7), and the South Prong (A.8 and A.9). Land use along the river (Florida Department of Environmental Regulation 1976a) is primarily agricultural (63 percent), forest (21 percent), industrial (9 percent), marsh-swamp (3 percent), and other (4 percent). Phosphate mines, both active and inactive, dominate the eastern reaches of the river, and vegetable farming is very prominent in the coastal area. The remainder of the area includes numerous small citrus groves and improved pasture interspersed with many fish ponds and confined feeding areas. Improved and unimproved pasture and scattered specialty farms dominate the area south of the river proper. North of the river are the rapidly developing areas of Brandon, Valrico, and Dover. Although much of the soil of the area is not suitable for the installation of septic tanks, most homes utilize this form of waste treatment.

The Alafia River proper is greatly influenced by Lithia Springs and Buckhorn Springs, but their contributions to the flow vary greatly between the wet and dry seasons: contributions to total flow may vary from 12 to 27 percent during low flow (October-May) and are usually less than 10 percent of total flow during wet seasons. The spring water is low in phosphate (0.05-0.1 milligram per liter), moderate in fluorides (0.3-0.6 milligram per liter), and low in TOC, BOD, and nitrogen species. except for nitrate-N (1.5-2.4 milligrams per liter). Although concentrations of dissolved oxygen are generally above 5.0 milligrams per liter, they vary widely and are often reported to be less than 50 percent saturation (Tampa Bay Regional Planning Council 1977c).

The area north of segment A.10 contains many inactive phosphate mining sites. The low BOD values (1.1 milligrams per liter on Plate 4) coupled with the high total phosphorus concentrations (8.98 milligrams per liter) indicate the probability of some seepage from older mining activities nearby (Tampa Bay Regional Planning Council 1977c).

The North Prong of the Alafia River flows in poorly defined channels through a wide marsh and swamp area subject to prolonged flooding. The major tributaries are English and Poley creeks. Abandoned and partially reclaimed phosphate mining activities mark the area, and major phosphate chemical plant activities are located immediately east of the Polk County line. The city of Mulberry discharges secondary-treatment domestic sewage into the North Prong. A large amount of nutrient loading comes from agricultural runoff. (See the point-source discharges on Plate 1 and Table 2.3)

The South Prong originates in Polk County in Hooker's Prairie and drains approximately 120 square miles of poorly drained soil. The flow is largely interrupted by phosphate mining activities. There has been some speculation that the Alafia River may reenter the ground into the Hawthorn formation between the South Prong and the main stem (Borden 1975). Immediately west of the Polk County line, the South Prong has significant concentrations of total phosphorus, but phosphate concentrations are significantly less within the next 3 to 4 miles, apparently because of natural swamp vegetation and aquatic plants' use of phosphate. Dissolved fluoride concentrations have been found to be high (Tampa Bay Regional Planning Council 1977c) and to fluctuate with streamflow and groundwater influences. Fluoride concentrations have been found to diminish from the county line to the mouth of the south prong (segments A.8 and A.9, Table 1.31).

The major sources of inorganic phosphorus in the Alafia River are phosphate mining and fertilizer production, natural leaching of soil and rock rich in phosphorus, and runoff from fertilized agricultural land. Phosphorus concentrations in most Florida streams average 0.1 milligram per liter, but natural surface waters in the Hillsborough and Polk County area contain background concentrations approximating 1.5 milligrams per liter SFWMD 1975). Extracting phosphate industry loading to the Alafia River from Table 2.9 yields the following:

	ADF (mgd)	TSS (lb/day)	TP (lb/day)	TF (lb/day)
Phosphate mining	54.0	7622	2120	2893
Phosphate processing	12.7	1968	48	108
Total	66.7	9590	2168	3001

In some segments of the Alafia River (A.2, A.3, A.6, A.11), ammonia-N concentrations are very high because of large contributions by wastewater contaminated with ammonia; this contamination is due largely to the large increase in production of ammonia and fertilizers in recent years. Fluoride concentrations were found by Toler (1967) to range from 3.2 to 30.0 milligrams per liter; the remainder of the state has natural levels of 0.2 to 0.4 milligram per liter. These high levels have been attributed to phosphate mining and fertilizer processing.

The presence of coliform bacteria in water indicates possibly dangerous pollution from sewage. Fecal contamination caused by septic-tank drainage and improperly treated sewage effluent is a local problem in the Alafia River Basin. Large sections of the river are often posted by the Hillsborough County Health Department to warn against swimming because of high coliform concentrations (Southwest Florida Water Management District 1975). Before the Alafia River Basin was extensively urbanized and developed, the surface-water quality presented no significant problems for any type of water use although natural pollution was present in the form of swamp drainage associated with organic acids that impart a brown tint to water and lower the pH. As development pressures increased, the quality of the surface-water systems steadily deteriorated to the present condition. The principal sources of man-induced wastes in eastern Hillsborough and western Polk counties are phosphate mining, nitrogen and phosphorus fertilizer production, agricultural and urban runoff, and domestic sewage (Southwest Florida Water Management District 1975).

e. Little Manatee River

The Little Manatee River originates near Ft. Lonesome and flows about 40 miles to Tampa Bay; it contrasts rather sharply with its northern neighbor, the Alafia. The headwaters of major tributaries to the Little Manatee have gradient drops of 8.8-14 feet per mile; the fall is about 7 feet per mile near Ft. Lonesome and averages less than 1 foot per mile in the lower portion near the coast. The overall average fall for the 40-mile distance from the Little Manatee's headwaters to its mouth is 3.4 feet per mile. The mainstem Little Manatee River from headwaters to its confluence with the South Fork (LM.1) drains an area that is heavily agriculturally oriented, and high runoff from the agricultural land during the rainy season produces high concentrations of phosphorus, organic nitrogen, and ammonia. Significant groundwater contribution has been suspected because of the higher-than-average fluoride concentrations, dilution of color, and increases in solids, BOD, turbidity, conductivity, and pH during high river flow (Tampa Bay Regional Planning Council 1977c).

The South Fork of the Little Manatee (LM.2) begins with a headwater gradient of 21 feet per mile and drains 15,260 acres of rangeland, 1,140 acres of cropland, 1,100 acres of citrus groves, and 110 acres of specialty farms. There are no significant urban areas, mining activities, or point sources. The highest single family development along the river is in segments LM.3 and LM.4, but there have been no significant pollutional loads other than slightly increased nutrient concentrations (probably related to agricultural runoff) during increased rainfall intensity (Tampa Bay Regional Planning Council 1977c).

f. Manatee River

The Manatee River is surrounded mostly by level plains in the headwaters and low, nearly level plains and gently undulating terrain in its western reaches and coastline area. Surrounding segment M.1 are fairly extensive wetlands; more than 70 percent of the land in this segment is either unimproved or improved pasture, and numerous areas of cropland and citrus groves are scattered throughout. Occasional high phosphate and nitrogen concentrations (particularly organic nitrogen) are indicative of runoff from agriculture and pastureland.

The primary source of drinking water for the residents of Manatee County is Lake Manatee (in segment M.2). There is little development along the shoreline except for the northeastern portion's extensive citrus groves; the remainder of the area around M·2 is predominantly pasture. Results of Manatee County Health Department water quality investigations before and after storms indicate runoff contamination from surrounding pastureland; nitrate and phosphate concentrations are high and dissolved oxygen low.

North of segment M.3 around Gamble Creek is an extensive drainage-ditch system that drains unimproved and improved pasture. Water quality data taken by county agencies indicate that runoff from pastures in the Gamble Creek area contributes significant pollutional loads of bacteria, suspended solids, phosphate, and total Kjeldahl nitrogen. The western portion of segment M.3 from Gamble Creek to the mouth of the river is considered estuarine. Three land zones can be identified:

- The area between Ft. Hammer and Rocky Bluff and most land south of the Manatee River is pastureland abundant with estuarine and tidal marshes
- Row crops and citrus groves having an extensive system of drainage ditches dominate between Rocky Bluff and U.S. Highway 19
- The urban areas of Palmetto and Bradenton are located between U.S. 19 and the coast.

The point-source discharges in this segment are identified on Plate 1 and Table 2.3. Water quality data collected in this segment indicate excessively high total coliform counts, low dissolved oxygen, and high total phosphorus, total Kjeldahl nitrogen, and suspended solids.

g. Myakka River

The Myakka River headwaters consist of a number of small streams that drain swamps and marshes. Often during the dry season, the Myakka River, in its shallower reaches, is completely dry. Around segment MY.1, land is primarily agricultural with 75 percent in unimproved and improved pasture; the only urban center in this segment is the small community of Myakka City. One point source exists near the headwaters of Wingate Creek - Becker Phosphate Corporation (see Plate 1 and Table 2.3). Concentrations of phosphorus, ammonia, and organic nitrogen are high. The high nutrient concentrations are probably the result of a combination of runoff from agricultural land and the phosphate plant discharge.

The remainder of the Myakka River (MY.2-MY.5) flows through land that is used primarily for agriculture but is interspersed with many wetlands. Proceeding from MY.1 through MY.5 (Plate 4), one generally finds that the pH increases, indicating the reduced influence of swamp and marshlands on water quality as the river approaches its mouth. A fairly high TOC concentration within segment MY.2 is indicative of the drainage from the woodland area within Myakka River State Park.

h. Big Slough Canal

Big Slough Canal is a major sub-basin of the Myakka River Basin; it flows southwesterly from its headwaters in a swamp-marsh east of Myakka River State Park, joining the Myakka River at North Port. Classified as Class I from its headwaters to U.S. Highway 41, the canal provides a portion of the water for North Port. The water quality is greatly influenced by runoff from surrounding swamp and marsh areas, being high in nitrate and color.

i. Horse Creek

Most of the land surrounding Horse Creek is either marsh, cropland, or forest. High color and organic nitrogen and phosphorus concentrations (Plate 4) indicate the influence of swamp and agricultural runoff, but there are presently no identified dischargers.

j. Shell Creek

Shell Creek, which provides the water for Punta Gorda, is formed by many small tributaries that meander through the extensive marshland northeast of Charlotte Harbor. It is joined from the north just east of Ridge Harbor by Prairie Creek, the headwaters of which are in Tiger Bay Slough. Both Prairie Creek and Shell Creek are Class-I waters (suitable for public water supply) from their headwaters to Ridge Harbor. Ammonia and organic nitrogen concentrations are fairly high, indicating influence from swamp drainage.

k. Peace River

The Peace River lies within two natural topographic regions of Florida - the Coastal Lowlands and the Central Highlands. The headwaters are in an area known as the Green Swamp. The two principal tributaries forming the Peace River are the Peace Creek Canal and Saddle Creek. The river drains several lakes including Haines, Fannie, Hamilton, Rochelle, Howard, and Hancock. Most of the basin is characterized by poorly drained soils of thick acid sands with organic pans.

From its headwaters to its mouth at Charlotte Harbor (approximately 105 miles), the Peace River receives drainage and effluents from industrial activity (particularly phosphate mining within Polk County), urban areas (Bartow, Ft. Meade, Bowling Green, Wauchula, Zolfo Springs, Arcadia, and Punta Gorda), and a variety of land uses including agriculture (along the entire length), forest (predominantly in segments P.1-P.6), marsh and floodland (particularly surrounding segments P.7-P.14), and recreation (particularly areas P.11-P.14). The influence of drainage from different land uses and domestic or industrial discharges is seen in the water quality data presented on Plate 4 (in pocket).

Color values, which are commonly associated with swamp drainage, are higher along the lower portions of the Peace River where marshes and swamps are extensive. Fluoride and total phosphorus concentrations generally decrease from area P.3 to Charlotte Harbor, indicating contamination from phosphate activities along the upper stretches of the river (P.3 and P.4). The following results are obtained by extracting industry loading data for the Peace River from Table 2.9:

	ADF (mgd)	TSS (lb/day)	TP (lb/day)	TF (lb/day)
Phosphate mining	12.1	1,268	1,344	387
Phosphate processing	1,215.6	11,252	9,571	5,693
Total	1,227.7	12,520	10,915	6,080

One of the concerns of water and land users regarding phosphate activities along the Peace River is the possibility of slime spills. One of the worst occurred on December 3, 1971, when the dam failed at a slime pond on Whidden Creek; approximately 1 billion gallons of phosphatic clays flooded down the river. The flow of the river was increased by a factor of 6, with a recorded phosphorus concentration of more than 7,000 milligrams per liter (Southwest Florida Water Management District 1975). Sediments were deposited more than 6 feet deep in parts of the river channel, and a 3-inch layer was left in Charlotte Harbor 70 miles downstream. Whidden Creek suffered the most damage, and most animal habitat was eliminated (Southwest Florida Water Management District 1972). After completing a study later in December 1971 following the spill, the Florida Game and Freshwater Fish Commission concluded that 21 species of fish had been totally eliminated from the river; the total fish kill was estimated to be between 85 and 90 percent (Southwest Florida Water Management District 1972).

3. Water Quality Regulations and Violations

Water quality is controlled in Florida by both federal and state rules and guidelines. The state's water quality standards must be at least as stringent as the federal rules and can be more stringent. There are rules relevant to pollutant concentrations and overall quality that must not be violated within particular surface-water segments (water quality-limited) as well as rules relevant to pollutant concentrations and overall quality of effluents discharged into surface-water bodies (effluent-limited). State rules applicable to domestic and industrial effluents as well as those applicable to the water quality of various classifications of water are presented in Chapter 17-3 of the Rules of the Florida Department of Pollution Control.

a. Effluent Limitations

Domestic dischargers are required to meet effluent regulations that reflect the latest technological advances in waste treatment and are approved by the appropriate regulatory agency. These regulations generally require at least secondary waste treatment (i.e., 90 percent removal of pollutants) and in many cases (e.g., for treatment facilities that discharge their wastes into any part of the Tampa Bay system or any bay or sound along the western shore of the study area) require advanced waste treatment or alternate effluent disposal. Advanced waste treatment produces an effluent not exceeding the following concentrations (milligrams per liter): 5-day biochemical oxygen demand , 5 ; total suspended solids, 5; total phosphorus, 1; and total nitrogen, 3. Alternate effluent disposal calls for secondary treatment as a minimum, followed by an effluent disposal system (i.e., land disposal and deep well injection approved by the Florida Department of Pollution Control) that prevents any effluent from being discharged to surface waters.

Industrial wastes are regulated by uniform technology-based effluent limitations set forth in Section 301 of the Federal Water Pollution Control Act of 1972 (Public Law 92-500). Two levels of effluent limitations are established. The first level is defined as the "best practical control technology currently available" (BPT). Industrial dischargers must have attained the production of effluents meeting the guidelines for BPT no later than July 1, 1977. The second level is defined as the "best available technology economically achievable" (BAT). Industrial dischargers must have attained the production of effluents meeting the guidelines for BAT by July 1, 1983. For the Florida phosphate industry, the prescribed guidelines for BPT and BAT effluents are set forth in Title 40, Code of Federal Regulations (CFR), Part 436, and Title 40, Code of Federal Regulations, Part 418. The Florida Department of Environmental Regulation has contested the criteria that the U.S. Environmental Protection Agency used for establishing BPT and

BAT guidelines, feeling that the empirical data incorporated were not exemplary of the best technological methodologies. The remainder of this discussion concerning BPT and BAT will use EPA's guidelines for mining and chemical processing plants. The regulations to be applied in attaining BPT and BAT can be summarized as follows:

- Mining and Beneficiation

Waste effluents must meet the following regulations:

BPT/BAT	30-Day Avg	Daily Max
Total suspended solids	30 mg/l	60 mg/l
pH	6.0-9.0 units	6.0-9.0 units

Any facility designed to contain wastewater up to the 10-year 24-hour rainfall event is not subject to these limitations.

- Chemical Processing

BPT

All "process" (as defined in 40 CFR 436) wastes must be contained to a volume equal to the 10-year 24-hour rainfall event. Effluent discharges allowed when the containment volume reaches the midpoint of the surge capacity must meet the following requirements:

Total suspended solids	50 mg/l	150 mg/l
Total phosphorus	35 mg/l	105 mg/l
Total fluoride	25 mg/l	75 mg/l
pH	6.0-9.5 units	6.0-9.5 units

"Contaminated nonprocess" wastewater (as defined in 40 CFR 436) must meet the following requirements:

Total phosphorus	35 mg/l	105 mg/l
Total fluoride	25 mg/l	75 mg/l
pH	6.0-9.5 units	6.0-9.5 units

BAT

All "process wastewater" (as defined) must be contained to a volume equal to the 25-year 24-hour rainfall event. Effluent discharges allowed when the containment volume is exceeded are the same as those for BPT. "Contaminated nonprocess wastewater" (as defined) must meet the same requirements as those for BPT.

The wastewater generated from the fertilizer industry in Florida is discussed in detail in a number of Environmental Protection Agency publications (e.g., USEPA 1974a, 1974b). Wastewater from phosphate mines includes surface runoff of rainwater into mines and water-treatment systems, groundwater seepage and infiltration into mines, and process water used to transport the ore to processing plants. The quantity of mine water is either unrelated or only indirectly related to a mine's production rate, so effluent limitations are expressed in terms of concentration rather than units of production. Mine dewatering discharges are regulated, but runoff water is not (USEPA 1976b). Wastewater from a processing facility includes transport water, ore and product washwater, classification water, heavy media separation water, flotation water, solution water, water from air-emissions control equipment, and water emanating from equipment and floor washdowns (USEPA 1976b) (see Volume I) of the working papers for a description of the phosphate industry activities).

Because of the unavailability of point-source discharge projections for a large portion of the 7-county study area, the effect of meeting BPT and BAT regulations will be analyzed only for phosphate industry loadings to stream segments in 1985 and 2000 under baseline conditions. Projection of the existing baseline is based on the assumption that only phosphate mines permitted as of August 1, 1977, will be allowed to continue operations; there will be no new chemical processing plants, and those in existence will continue to operate at their present rates through the year 2000.

Table 2.9 indicates existing discharges from phosphate mining and processing facilities. The information for the parameters regulated under BPT and BAT limitations was extracted from Table 2.3. The river segment

Table 2.9. Existing Discharges from Phosphate Industry Mining and Processing Facilities

	River Segment	Discharge No.	Period	ADF* (mgd)	TSS** (lb/day)	TP** (lb/day)	TF** (lb/day)
Processing	P.4	163	1976-2000	4.0	690	1112	204
	P.4	32	1976-2000	5.6	258	25	85
	P.5	171	1976-2000	2.5	320	207	98
	A.2	73a	1976-2000	1.44	272	83	55
	A.2	77	1976-2000	5.6	1110	127	644
	A.2	78	1976-2000	8.4	1214	517	504
	A.2	75	1976-2000	0.64	131	16	34
	A.4	85	1976-2000	1.0	255	56	25
	A.5	72	1976-2000		No discharge		
	A.8	82	1976-2000	3.1	791	106	50
	A.12	70b	1976-2000	33.8	3849	1215	1581
	TB.3	112	1976-2000	0.3	103	39	4
Mining/Beneficiation	P.1	176	1976-83	5.8	534	35	58
	P.3	73b	1976-82	5.76	382	97	61
	P.4	167	1976-90	0.9	8280	180	2970
	P.4	170	1976-90	7.4	901	48	68
	P.4	83	1976-90	1.8	174	3	18
	P.4	166	1976-85	10.5	925	85	255
	P.5	173	1976-83	1.4			
	P.7	174	1976-97	8.7^+	1961	72	128
	P.7	175	1976-83	25.8	5418	1966	733
	P.8	178	1976-90	14.8^+	1380	163	249
	P.8	177	1976-2000	6.8^+	364	62	72
	A.2	76	1976-90	0.4	84	2	3
	A.2	73b	1976-2000	4.32	778	19	37
	A.2	80	1976-2000		No discharge		
	A.8	87	1976-88		Insignificant		
	A.8	86a	1976-95	2.7	351	14	41
	A.9	86b-c	1976-95	5.3	755	13	27
	A.9	90	1976-94		Insignificant		

*Florida Department of Environmental Regulation (1976a, 1976b) unless followed by + to indicate USEPA (1977).

**Except for discharge 70b, the average loadings were determined from instantaneous data collected by the USEPA (1977). The following calculation was used:

$$TV = PF \times \frac{EPA(v)}{EPA(f)}$$

where:

TV = table loading value
PF = published (Florida Department of Environmental Regulation 1976a, 1976b) average flow
EPA(v) = instantaneous loading value (USEPA 1977)
EPA(f) = instantaneous flow (USEPA 1977)

receiving the discharge (refer to Plate 1) and the period of time during which the facility has been in operation (see Volume I) are also given. Unfortunately, discharge monitoring records were not available for all facilities, but other information sources helped to compensate for this lack of information. In many instances, the discharge flow data are estimates because of the use of improper flowmetering devices (USEPA 1977). Since many facilities mix their process and nonprocess wastewaters before discharge, the flow contributed by the two categories is not available: thus, EPA publications (USEPA 1975, 1976a) were consulted in order to determine the percentage of wastewater effluents contributed by both process and nonprocess wastes.

At all beneficiation plants, at least 65 percent (and up to 95 percent) of process water is recycled; most of the remaining water is tied up in slimes. All beneficiation plants intermittently or continuously discharge effluents from one or more settling areas. Most discharges are intermittent, i.e., heavy during the wet season and light-to-nonexistent during the dry season. Wastewater volumes are related to each facility's amount of recycling, rainfall frequency, surface runoff, and available settling-pond acreage (USEPA 1975). Surface runoff is the only wastewater normally occurring in mining areas; often uncontrolled, this runoff entrains minerals, silt, sand, clay, organic matter, and suspended solids, carrying them to the receiving stream.

The Florida Department of Environmental Regulation (nd), in providing criteria for BPT and BAT limitations stricter than those proposed by the EPA, determined that the latter's "no discharge" limitation would account for approximately 90 percent of the effluent being discharged into the Peace and Alafia rivers and that the remaining 10 percent would be subject to the EPA's industrial-waste guidelines for discharge.

Based on the information just presented and because of the unavailability of data to distinguish process wastes from nonprocess wastes, the following assumptions were made for the ensuing discussion:

- All discharge volumes from mining/beneficiation are nonprocess wastes.
- 10 percent of the discharge volumes from processing plants are nonprocess wastes, and the remaining 90 percent are process wastes subject to total retention under BPT and BAT guidelines.

Projected 1985 and 2000 loadings (Table 2.10) were calculated by using (1) 100 percent of the mining effluent of 1976 as nonprocess waste and the BPT and BAT allowable concentrations for mine effluents and (2) 10 percent of the chemical processing plant effluent as nonprocess waste and the BPT and BAT allowable concentrations for the chemical processing effluents. Table 2.11 summarizes the effects.

Table 2.10. Present and Projected Mining/Beneficiation Water Quality Parameter Loadings

	Effluent	Present Conditions Peace R.	 Alafia R.	1985 (BPT in force) Peace R.	 Alafia R.	2000 (BAT in force) Peace R.	 Alafia R.
Mines	Average daily flow (mgd)	89.7	12.7	50.9	12.72	6.8	4.32
	Total suspended solids (lb/day)	20,319	1,968	12,735	3,182	1,701	1,081
Processing	Average daily flow (mgd)	12.1	54.0	1.2	5.40	1.2	5.4
	Total suspended solids (lb/day)	1,268	7,622	-	-	-	-
	Total phosphorus (lb/day)	1,344	2,120	350	1,576	350	1,576
	Total fluorides (lb/day)	387	2,893	250	1,126	250	1,126

Table 2.11. Effluent Reductions Produced by BPT and BAT

	Percentage Reductions					
Effluent	BPT (from present) Peace R.	 Alafia R.	BAT (from present) Peace R.	 Alafia R.	BAT (from BPT) Peace R.	 Alafia R.
Average daily flow	48.8	72.9	92.1	85.4	84.6	46.3
Total suspended solids	40.5	66.8	92.1	88.7	86.6	66.0
Total phosphorus	91.4	27.3	91.4	27.3	0.0	0.0
Total fluoride	95.0	62.5	95.0	62.5	0.0	0.0

b. Water Quality Limitations

Even though all discharges to surface waters may meet effluent requirements, a large number of discharges to the same stream segment may degrade the water quality below acceptable limits. Water quality limitations developed for the state of Florida are based on the intended uses of the water within specific segments. Chapter 17-3 of the Florida Administrative Code contains the water quality criteria for the various water classifications. Florida defines five classes of water based on intended use:

- Class I (public water supply): water withdrawn for treatment and distribution as potable
- Class II (shellfish harvesting): water that is actually or potentially capable of supporting recreational or commercial shellfish propagation and harvesting
- Class III (recreation and propagation and management of fish and wildlife): water used for recreation such as swimming and water skiing and for maintaining a well-balanced fish and wildlife population, plus all surface water within and coastal waters contiguous to basins, including offshore waters, not otherwise classified
- Class IV (agricultural and industrial water supply): water to be used for agriculture or stock watering or as an industrial water supply, plus all secondary and tertiary canals wholly within agricultural areas
- Class V (navigation, utility, and industrial uses): water suitable for navigation and any uses other than those previously classified

Table 2.12 displays the surface-water segments defined in subsection B and gives the appropriate classification for each. (Plate 4 provided the data used for determining whether violations exist.) The factors contributing to the inferior water quality of particular segments are discussed in subsections B.1 and B.2.

Of the 62 segments investigated, only one (A.1) failed to show a violation; however, there were no data available for the parameters that produce the highest percentage of violations (nitrate, ammonia, and phosphate) and segment A.1 is the only segment in the phosphate activity center near

Table 2.12. Water Quality Violations[†]
(Page 1 of 2)

Designation on Map	Water Body Classification	Dissolved Oxygen (mg/l)	Alkalinity (mg/l $CaCO_3$)	Color (Pt - Co unit)	Fluoride (mg/l)	Nitrate-N (mg/l)	Ammonia-N (mg/l)	pH (pH unit)	Ortho Phosphate (mg/l)	Turbidity (JTU)	Total Coliform (No./100 ml)	Conductivity (mho/cm)
P.1	III	• 0.5	–	–	•14.0	• 5.70	• 0.17a	• 9.2	NA	• 32.0	NA	–
P.2	III	• 0.6	•16	–	–	• 0.57	• 0.15a	–	NA	–	NA	–
P.3	III	• 1.7	•13	–	• 5.2	• 0.33a	• 0.18a	• 4.8	NA	•150.0	NA	• 790
P.4	III	• 1.0	–	–	• 7.0	• 0.75a	• 0.43a	• 5.6	NA	• 59.8a	• 2,700a	• 600
P.5	III	–	–	NA	•15.5	• 0.87a	• 1.47a	–	NA	• 40.2a	NA	NA
P.6	III	–	•10	NA	–	• 0.50a	• 0.05a	• 5.8	NA	–	NA	NA
P.7	III	• 0.4	• 8	–	•18.0	• 1.23a	• 0.44a	• 4.0	• 5.19a	–	• 5,100	• 530
P.8	III	–	•18	NA	–	• 1.25a	• 0.13a	–	NA	NA	NA	NA
P.9	III	• 0.0	–	–	• 8.6	• 1.23a	• 0.22a	• 4.2	• 4.86a	•160.8a	• 2,735a	• 742
P.10	III	–	•16	–	NA	NA	NA	–	NA	–	NA	–
P.11	III	• 2.3	•15	–	–	• 1.13a	• 0.11a	NA	• 1.00a	• 59.0	• 7,000	• 630
P.12	III	–	–	–	–	• 1.00a	• 0.16a	–	NA	• 56.0	–	• 605
P.13	III	NA	• 0	–	–	–	–	• 4.3	–	–	NA	• 990
P.14	III(m)	–	–	–	–	• 0.64a	• 0.45	–	NA	–	–	–
A.1	III	–	–	–	–	NA	NA	–	NA	–	NA	–
A.2	III	–	•8	–	•12.3a	• 0.81a	• 4.31a	• 4.9	NA	–	NA	• 680
A.3	III	–	–	–	• 5.7a	• 0.43a	• 1.18a	• 4.0	NA	–	NA	• 660
A.4	III	–	•12	NA	–	• 1.00	• 0.19a	• 4.4	NA	NA	NA	NA
A.5	III	–	•14	–	•44.0	• 0.94a	• 0.24a	• 9.2 • 5.5	•21.09a	• 28.0	NA	• 560
A.6	III	• 2.2	• 2	–	•10.7a	• 0.91a	• 0.70a	• 4.8	NA	• 30.0	NA	• 833a
A.7	III	• 1.1	• 4	–	–	• 0.79a	• 0.23a	• 5.8	•22.07a	–	• 5,226a	–
A.8	III	• 3.0a	•16	NA	• 6.2a	• 1.00	• 0.35a	• 9.1 • 4.4	NA	–	NA	NA
A.9	III	• 0.8	• 2	–	• 6.6	• 1.20	• 0.11a	–	NA	–	NA	•2,450
A.10	III	• 1.8	• 0	–	• 5.8a	• 0.63a	• 0.22a	• 8.8 • 5.2	• 8.22a	• 30.0	–	• 599a
A.11	III	• 3.9	–	–	• 5.6a	• 1.45a	• 0.38a	–	•12.91a	• 28.0	• 3,042a	• 566a
A.12	III(m)	• 0.3	–	–	•12.0	• 0.57a	• 1.27	–	• 2.92a	–	• 2,445a	–
H.1	III	• 1.7	• 0	–	• 6.0	• 0.86a	• 0.37a	–	• 0.56a	–	• 5,883a	•1,580
H.2	I	• 1.7	–	•200	• 1.6	• 3.00	• 0.10a	• 9.3 • 4.6	• 1.80a	• 88.0	NA	• 614
H.3	I	• 0.9	–	•140	NA	• 0.48a	• 0.18a	• 8.6 • 4.7	NA	–	NA	–
H.4	I	• 1.5	•13	• 80	–	• 1.31	• 0.05a	–	NA	• 70.6a	–	• 907a
H.4	III(m)	• 1.5	•13	–	–	• 1.31	–	–	NA	• 70.6a	–	–
LM.1	III	• 3.1	•10	–	–	–	NA	–	NA	–	NA	•1,260
LM.2	III	• 2.0	–	–	–	–	• 0.04	–	NA	–	NA	• 890
LM.3	III	• 3.4	• 3	–	–	• 0.39	• 0.06a	–	• 0.52a	–	• 4,000	•1,500
LM.4	III(m)	• 3.6a	–	–	–	–	• 1.05a	–	NA	• 32.0	–	–
M.1	III	–	• 5	–	–	–	• 0.04a	• 5.5	NA	–	NA	–
M.2	I	• 0.0	•12	•160	• 2.7	• 0.85	• 0.08a	• 5.5	NA	–	•35,000	•6,816a
M.3	III(m)	–	NA	–	–	• 0.41a	• 1.33a	• 5.5	NA	–	–	–

Table 2.12 (Page 2 of 2)

Designation on Map	Water Body Classification	Dissolved Oxygen (mg/ℓ)	Alkalinity (mg/ℓ CaCO$_3$)	Color (Pt – Co unit)	Fluoride (mg/ℓ)	Nitrate-N (mg/ℓ)	Ammonia-N (mg/ℓ)	pH (pH unit)	Ortho Phosphate (mg/ℓ)	Turbidity (JTU)	Total Coliform (No./100 mℓ)	Conductivity (mho/cm)
MY.1	III	• 1.8	NA	–	–	+ 0.50	+ 0.12a	• 5.5	NA	+ 34.8	–	+1,400
MY.2	I	• 2.2	•12	+133a	–	–	+ 0.05a	–	NA	+ 70.0	NA	–
MY.3	III	–	•17	–	–	+ 0.32	+ 0.14a	–	NA	–	+ 2,533a	+1,600a
MY.4	II	–	NA	–	–	–	–	+ 8.7	NA	–	+ 637a	–
MY.5	II	–	NA	–	–	–	–	–	NA	–	+ 128	–
BS.1	I	• 0.0	NA	+120	–	+ 3.45a	NA	+ 9.0	NA	–	NA	–
BS.2	I III	– –	– –	+100 –	– –	– –	+ 0.16 + 0.16	– –	NA NA	+ 70.0 + 25.5a	NA NA	+ 585a + 585a
HC.1	III	–	•16	–	–	+ 0.44	–	• 5.6	NA	–	–	–
HC.2	III	• 1.4	•18	–	–	+ 0.44	–	• 5.7	NA	–	–	–
HC.3	III	• 1.3	•20	–	–	–	–	• 5.9	NA	–	–	+ 753
HC.4	I	• 1.3	–	+110a	–	–	+ 0.05a	–	NA	–	–	–
S.1	I	• 2.8	• 3	+100	–	–	+ 0.11a	–	NA	–	–	+ 796a
S.2	I	• 2.6	–	+200	NA	–	+ 0.22a	–	NA	–	–	+ 501a
S.3	I III	• 3.8a • 3.8a	– –	+107a –	– –	– –	+ 0.20a + 0.62	– –	NA NA	– –	– –	+ 575a –
TB.1	III(m)	• 0.0	–	–	–	+ 0.32	+ 1.20	+ 8.7	+1.88a	+ 27.0	+ 5,431a	–
TB.2	II III(m)	• 2.2 • 2.2	– –	– –	– –	+ 1.30 + 1.00	+ 1.10 + 1.10	+ 8.6 + 8.6	+1.08a +1.08a	– –	+ 551a + 6,400	– –
TB.3	II III(m)	• 0.5 • 0.6	– –	– –	– –	+ 0.82 + 0.82	+ 0.75 + 0.75	+ 8.6 + 8.6	+1.53a +1.53a	– + 32.0	+ 140a –	– –
CH.1	II(m)	• 0.0	NA	–	NA	–	–	–	NA	–	+ 130a	–
CH.2	II(m)	• 2.6	NA	–	NA	–	–	–	NA	–	–	–
CH.3	II(m)	–	NA	–	NA	–	–	• 5.6	NA	–	–	–
Total	62	61	54	57	56	60	58	61	17	60	37	55
Violations	61	41	29	11	18	41	48	32	16	21	18	29
% Violations	98.4	67.2	53.7	19.3	32.1	68.3	82.8	52.5	94.1	35.0	48.6	52.7

Note:

+ Value exceeds criteria or standard.

• Value is lower than criteria or standard.

a The average value violates the criteria or standard.

NA Not available.

– Symbolizes that there are no criteria for the particular segment or that there is no violation of the standard or criteria. The decision as to whether a segment violates a water quality criteria or standard is based on the following information for the appropriate water quality classifications:

Water Body Classification	Dissolved Oxygen (mg/ℓ)	Alkalinity (mg/ℓ CaCO$_3$)	Color (Pt – Co unit)	Fluoride (mg/ℓ)	Nitrate-N* (mg/ℓ)	Ammonia-N (mg/ℓ)	pH (pH unit)	Ortho* Phosphate (mg/ℓ)	Turbidity* (JTU)	Total Coliform (No./100 mℓ)	Conductivity (mho/cm)
I	4.0	20	75	1.4	0.30	0.02	6.0-8.5	0.06	50.0	2,400	500
II (marine)	4.0*	20		10.0	0.30	0.40*	6.0-8.5	0.06	50.0	70	500
III (fresh)	4.0	20		5.0	0.30	0.02	6.0-8.5	0.06	25.0*	2,400	
III (marine)	4.0*	20		5.0*	0.30	0.40*	6.0-8.5	0.06	25.0*	2,400	

*Criteria

Water quality criteria, standards, and water-use classifications from USEPA (1974).

the headwaters of the Alafia River that does not receive phosphate industry discharge.

Overall, the most common water quality violations within the study area are high concentrations of phosphate, ammonia, and nitrate and low dissolved oxygen. The high nutrient concentrations are indicative of runoff from the large amount of agricultural and phosphate industry activity in the study area. The low dissolved oxygen may be indicative of a number of influences including the stagnant situations found in many swamp and marsh areas, large imputs of BOD that lower the dissolved oxygen available in the water, and the nighttime use of oxygen by large masses of plants or the loss of plant cover during the high flow of the wet season and the subsequent loss of a daytime oxygen supply. The color violations are indicative of a large organic load either from farm and pasture runoff or from swamps and marshes. High fluoride concentrations are indicative of groundwater inflow, leaching of fluoride from exposed phosphate matrix, or discharge from phosphate mining and processing activities. Low pH may result from swamp and marsh drainage or from phosphate processing wastes. High pH may indicate temporary eutrophic conditions resulting from increased nutrient loading which causes algal blooms. Unacceptable turbidity values may result from sediment-laden runoff from exposed soils, urban runoff, flushing of swamp and marsh areas during high discharge in the wet season, or discharge of particulate matter from domestic or industrial sources. The high coliform concentrations indicate possible receipt of fecal contamination from adjacent land use activities.

C. GROUNDWATER

1. Overview

The natural chemical quality of the ground water differs from location to location in the aquifers within the study area. In some areas, contamination from agriculture, mining, or chemical processing has degraded the natural quality. In the coastal areas, overpumping of public-supply wells has resulted in some saltwater encroachment (U.S. Army Corps of Engineers 1977).

a. Water-Table Aquifer

The water in the water-table aquifer is generally soft and has a low dissolved-solids content (less than 100 milligrams per liter) except in the shoreline areas where the chloride content exceeds 250 milligrams per liter because of natural hydrologic events or natural saltwater encroachment that results from withdrawals of fresh water from wells. The construction of drainage canals and channels in some coastal areas has lowered the water-table aquifer and apparently caused some inward migration of salty water (discussed in more detail later in this subsection). Locally contaminating the water-table aquifer are nutrients from fertilized agricultural land, leakage from sewers, and seepage from industrial lagoons, septic systems, and landfills. Contamination of the water-table aquifer is generally evidenced by increased concentrations of dissolved constituents such as chloride, nitrate, fluoride, phosphate, sulfate, and in some areas bacteria and viruses (U.S. Army Corps of Engineers 1977).

b. Floridan Aquifer

The Floridan aquifer is one of the most dynamic and productive groundwater systems in the world. It is a huge underground freshwater reservoir stretching the length and breadth of Florida and, according to most estimates, containing more water than the Great Lakes combined (International Minerals and Chemical Corporation 1976). It is underlain naturally at various depths by highly mineralized nonpotable water. Water obtained from the Floridan aquifer at inland locations in the study area generally can meet U.S. Public Health Service existing (1962) limits for drinking water supplies and the EPA's new Interim Primary Drinking Water Regulations (U.S. Army Corps of Engineers 1977). However, as seen in Figure 1.26, the Flordian aquifer of the lowland and coastal areas from Tampa Bay to Charlotte Harbor essentially contains no potable water.

The fresh water in the aquifer in the study area is primarily a calcium bicarbonate type that is slightly-to-moderately mineralized. The dissolved-solids content is normally 150 to 350 milligrams per liter, and the hardness of the water is classified as moderately hard to hard according to the following classification scheme (Sawyer 1960):

Concentration (mg/l as $CaCO_3$)	Description
0 to 75	Soft
75 to 150	Moderately hard
150 to 300	Hard
300	Very hard

Fluoride concentrations generally are low but may be as high as 3 to 4 milligrams per liter in some areas. Sulfate concentrations in the deeper zones commonly range from several hundred to several thousand milligrams per liter, and the water becomes increasingly salty below the high-sulfate zone. In the secondary artesian aquifer overlying the Floridan aquifer, the water is generally of good quality although the fluoride content may be locally high.

In general, man's activities have not contaminated the Floridan aquifer to problem proportions in the study area, but increased urbanization and industrialization may result in greater hazards in the future. There has been some encroachment of salty water locally in Gulf and bay shoreline areas because of heavy pumping of wells or dredging of channels and canals, but it is not a major threat regionally: there is essentially no evidence of significant upconing of salty water beneath heavily pumped wells in inland areas. However, because tongues or lobes of salty water in stream channels may extend inland far enough to threaten underlying aquifers, the SWFWMD is constructing barriers on several streams in the Tampa Bay area to retard this inland movement.

Kaufman (1967) characterized the chemical character of the water of the Floridan aquifer in the southern Peace River Basin. He found that water movement is heterogeneous because of the presence of solution channels and fractures. Chloride concentrations increase toward the southwest, with the greatest concentrations in the southernmost part of the Peace River Basin near Charlotte Harbor. Furthermore, Kaufman concluded that the water is primarily the calcium bicarbonate type in western and eastern Hardee County and eastern DeSoto County; a calcium-magnesium sulfate type along the

Peace River in central Hardee County, western DeSoto, and southeastern Sarasota counties; and a sodium chloride type in most of Charlotte County. Generally, the water underlying the Peace River is warmer and more mineralized than the water at equivalent depths a short distance to the east or west of the river. Kaufman (1967) identified areas of local recharge (northeast Manatee and northwest and northeast Hardee counties) and areas of local discharge (along the Peace River boundary) in the southern Peace River Basin, concluding that water along the southern Peace River Basin in the area of influence of ascending artesian water (discharge) generally is of poorer quality than water outside this area (excluding the sodium chloride water of Charlotte County).

Miller (1977) discusses the relationship of natural groundwater to geology, pointing out that:

- The chemical nature of ground water evolves from its interaction with rock materials and the length of time it is in contact with the rocks. The chemical character of the water is generally consistent where the rocks are similar in composition over broad areas; where there are localized occurrences of soluble, atypical minerals, the chemical quality of local ground water reflects those minerals.
- Because ground water is not static but constantly in motion, the water's quality commonly changes as it moves within an aquifer. As it first enters the ground, its chemical character resembles that of rainwater but, as it moves through the earth, its composition is influenced more and more by the chemical character of the rocks. In highly permeable but areally-limited surficial sand aquifers, circulation is rapid and water quality generally good; in extensive aquifers, water can migrate many miles from the intake area to the discharge area, generally increasing its mineral content. The relative concentrations of some constituents change (e.g., softening during movement through greensands). Consolidated rock aquifers are quite variable in their circulation capability, generally having only limited circulation below depths of approximately 152 meters (500 feet); at greater depths, the water can be highly mineralized, having high chloride and total dissolved solids as its primary objectionable constituents.

For a better understanding of the adverse effects of groundwater contamination, Miller (1977) reviews the principles governing the movement of pollutant-containing water within the groundwater system. Figure 2.6

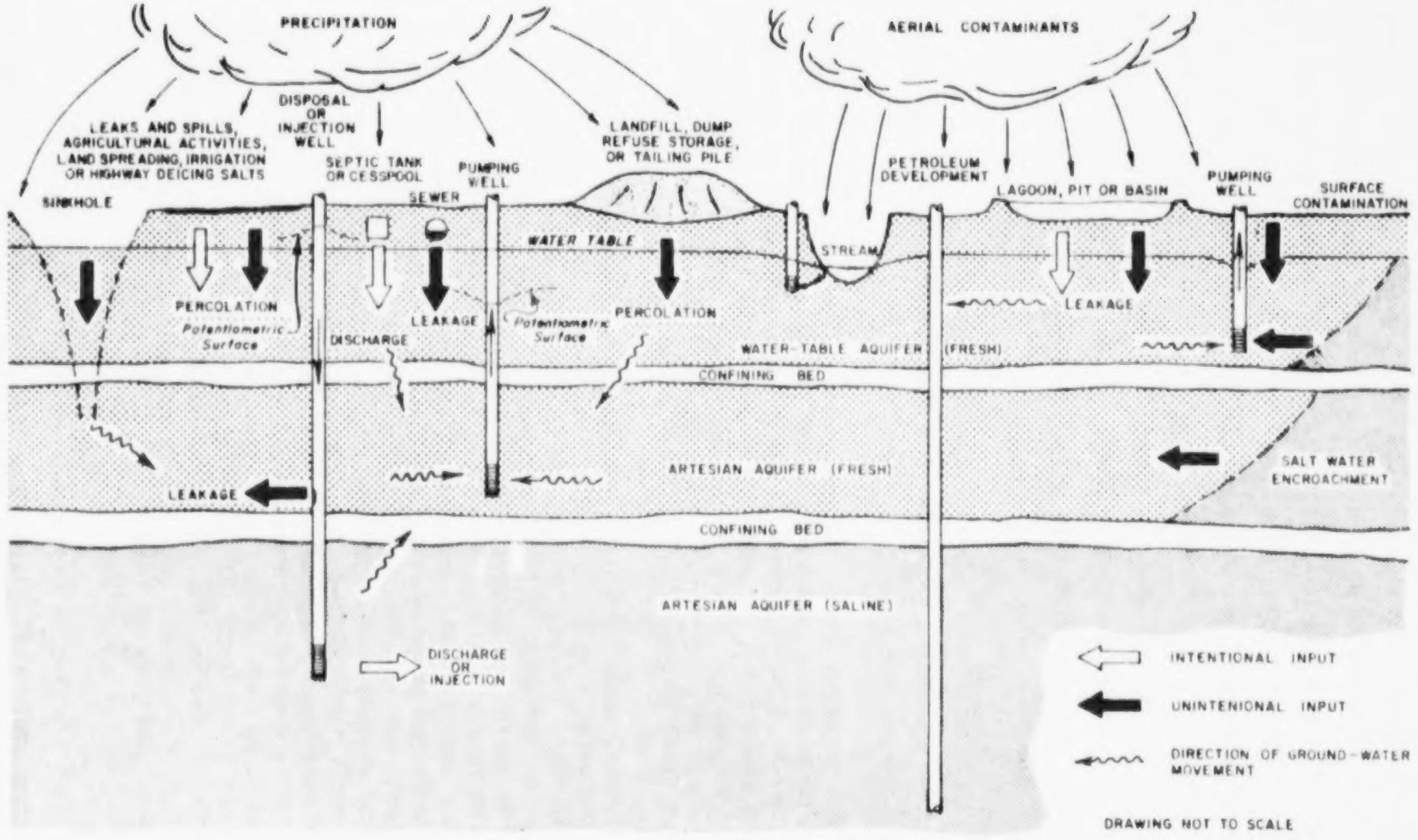
PRECIPITATION
AERIAL CONTAMINANTS
LEAKS AND SPILLS, AGRICULTURAL ACTIVITIES, LAND SPREADING, IRRIGATION OR HIGHWAY DEICING SALTS
DISPOSAL OR INJECTION WELL
SEPTIC TANK OR CESSPOOL
SEWER
PUMPING WELL
LANDFILL, DUMP REFUSE STORAGE, OR TAILING PILE
PETROLEUM DEVELOPMENT
LAGOON, PIT OR BASIN
PUMPING WELL
SURFACE CONTAMINATION
SINKHOLE
WATER TABLE
STREAM
PERCOLATION
Potentiometric Surface
DISCHARGE
LEAKAGE
Potentiometric Surface
PERCOLATION
LEAKAGE
WATER-TABLE AQUIFER (FRESH)
CONFINING BED
ARTESIAN AQUIFER (FRESH)
LEAKAGE
SALT WATER ENCROACHMENT
CONFINING BED
ARTESIAN AQUIFER (SALINE)
DISCHARGE OR INJECTION
INTENTIONAL INPUT
UNINTENIONAL INPUT
DIRECTION OF GROUND-WATER MOVEMENT
DRAWING NOT TO SCALE

Figure 2.6. Routes for Groundwater Contamination (Miller et al 1977)

shows the many different ways in which a contaminant can enter the groundwater system through man's activities. The contaminated fluid moves downgradient through the water-bearing material from point of entry to some lower-pressure discharge point at a rate that depends largely on the permeability of the earth materials and the hydraulic gradient in the groundwater system. In unconsolidated fine-grained sediments such as clay, ground water may move less than 3 meters (10 feet) per year under natural geohydrologic conditions; in sandy aquifers, the movement is rarely more than 152 meters (500 feet) per year; and even in very permeable gravel units, the rate of migration probably would not exceed 762 meters (2,500 feet) per year. Distance and rate can be considerably greater if the contaminated fluid moves through fracture zones or solution cavities of rock formations. Also, if well-pumping has lowered groundwater levels in the aquifer, the pollutant can move more quickly toward the center of pumping. The concentration of the pollutant affects its movement. Miller (1977) points out the various processes that can affect this:

- Adsorption by the materials through which the contaminated water passes
- The contaminated water's density with respect to that of natural ground water
- The manner in which the contaminated water spreads or disperses as it travels (e.g., even dispersal, solution cavities)

The quality of ground water within the study area is of significant concern: not only is the ground water the source of drinking water for about 91 percent of Florida's population, but the groundwater discharge represents a major portion of the base flow to many of the streams which, during the dry season, may be 100 percent of the streamflow. Since stream water quality criteria are based on concentrations during low flow, it is essential to maintain the quality of ground water in order to protect surface water.

Some of the principal sources of groundwater contamination in the study area include surface impoundments, landfills, land surface leaks and spills, septic tanks, saltwater encroachment, mining activities, feedlots, and agricultural percolation of pesticides and fertilizers (Miller 1977). In much of the study area, the possibility of saltwater intrusion is of great concern. Drainage canals and other tidal channels, as well as pumping near the coast, reduce the potentiometric head, causing the edge of the freshwater lens to retreat due to pressure loss and be slowly replaced by a landward migration of the saltwater wedge. Of course, this same effect occurs naturally to some degree due to tides and high water caused by hurricanes, but these events are of short duration compared with man's long-term interference with the natural hydrogeologic regime. Because the natural gradient of fresh ground water is toward the sea, water removed by tidal ditches, canals, and inland wells is replaced by fresh ground water flowing into a slightly seaward-tilted cone of depression; should the elevation of the lower edge of the cone (nearest to the sea) equal or be below sea level, there will be inland migration of salt water. The time interval for the salt water to reach a given well depends on the permeability and the hydraulic gradient.

The most serious problem caused by induced saltwater encroachment is the difficulty of reclaiming within a reasonable period of time the freshwater aquifer once it is lost to salt water. The problem is compounded if the subsurface materials are almost completely saturated (as they are along the coast in the study area). Intrusion in artesian aquifers can be controlled if the potentiometric surface along the coast is maintained above normal high tides; hurricane-induced high tides last only a few days, which is not enough time to cause any appreciable amount of saltwater subsurface flow into artesian aquifers. Along the coast, however, a hurricane tide of even short duration will affect water-table aquifers.

One of the major causes of saltwater encroachment into the shallow aquifer used for local water supply is saltwater intrusion at the mouths of rivers, creeks, and tidal ditches and canals along the coast. In addition, man agggravates this in several ways, primarily by the large number of tidal canals and drainage ditches constructed without dams to halt saltwater intrusions; these ditches not only lower groundwater levels by allowing more fresh water to drain from the land, but they convey saltwater inland during dry periods and flood tides, thus becoming inland extensions of the ocean.

Inland within the study area, the potential for saltwater contamination into the groundwater aquifers occurs largely from the pumping of water for agricultural activities. Most crop irrigation is during the winter growing season when water-table levels and streamflows are low. Since it is abundant, water from the Floridan aquifer having high chloride concentrations is often applied to the crops in excess of that required. This high-chloride water then percolates into the water-table aquifer, producing higher chloride concentrations. Because of the hydraulic gradient, this water may flow within the aquifer to points remote from the area of contamination.

Chloride occurs in almost all natural waters; some is contained in rainwater and some is dissolved from surface materials. After the water enters the ground, the chloride concentration generally increases because of solution of rocks and minerals through which the water percolates, mixing with connate water (water that was trapped in rocks when they were formed), encroachment of salt water from the ocean, or pollution. Sewage, industrial wastes, and fertilizers contain chloride. From Shampine's (1964a) investigations of chloride concentrations in the upper zone of the Floridan aquifer, it is obvious (Figure 1.14) that the most serious concern is in the southern portions of Sarasota County and the western and eastern portions of Charlotte County. In southwest Florida where the Floridan aquifer contains water under pressure with heads ranging from about 20 feet above mean sea level along the coastal margin to more than 50 feet above msl in the interior, wells drilled for irrigation over most of the area will flow at the surface. The chloride content of this water averages about 1,000 milligrams per liter. Although the water is used to irrigate salt-tolerant crops, an excessive amount is applied; thus, the excess percolates downward to the water table, increasing chloride concentrations in the unconfined aquifer. Some of the water also flows out of the area through surface drainageways to points at which the shallow aquifer is used extensively (Miller 1977).

Sulfate is found in almost all natural water; in rainwater, it is dissolved from impurities and gases in the atmosphere, and it may also be dissolved from materials on the surface of the ground (e.g., decaying organic matter such as leaves and trees). Sulfate is also discharged in various industrial wastes, and its concentration may increase upon entering the ground because of leaching from gypsum and other sulfate minerals, connate water contamination, salt water from the ocean, or pollutants. In the upper part of the Floridan aquifer in the coastal area, sulfate concentrations (Figure 2.7) are particularly high because of the influence of salt water from the ocean; this extends inland to occupy almost all of Sarasota County. Water from deeper zones usually contains greater concentrations of sulfate.

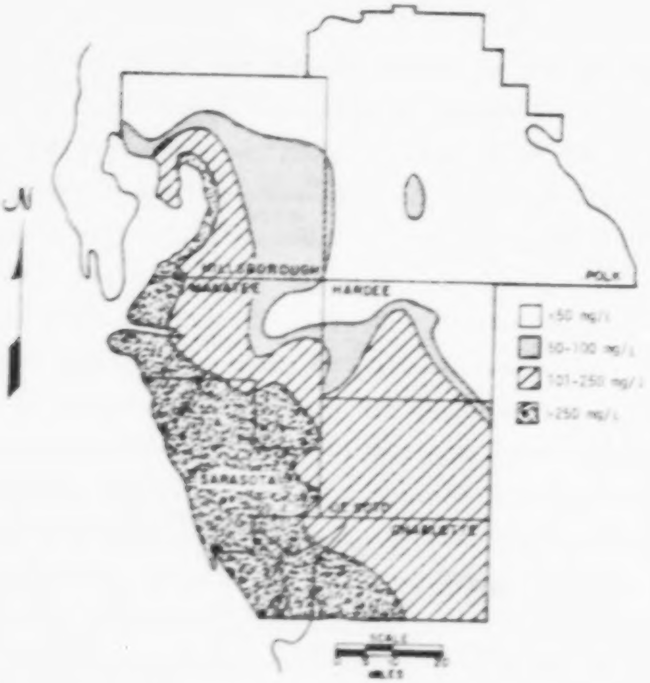

Figure 2.7. Concentrations of Sulfate in Water from Upper Floridan Aquifer (Shampine 1964b)

All natural waters contain dissolved solids - primarily carbonates, bicarbonates, chlorides, sulfates, phosphates, fluorides, and nitrates of calcium, magnesium, and sodium, with only small amounts of potassium, iron, manganese, strontium, and sulfide. Small amounts of solids usually are dissolved by rain from impurities in the atmosphere or come from surface materials. The dissolved solids generally increase after the water enters the ground because of the solution of rocks and minerals, mixing with highly mineralized connate waters, encroachment of salt water from the ocean, or pollution. Within the 7-county study area, the predominant constituents are sodium and chloride along the coast and throughout most of Sarasota County, sodium and carbonate throughout most of Charlotte County, and calcium and carbonate throughout the remainder of the study area. The dissolved-solids concentrations in the upper part of the Floridan aquifer are indicated in Figure 2.8. Highly mineralized water (concentrations of more than 500 milligrams per liter) occurs throughout Charlotte and Sarasota counties, in the western portion of Manatee County, and in the southwestern portion of Hillsborough County. The coastal city of Sarasota presently obtains its water supply from a well field at Verna, which is almost 32.2 kilometers (20 miles) inland from the coast, because local reserves of fresh ground water are limited; however, even at this inland location, the concentrations of some constituents such as dissolved solids and sulfate in the well water exceed recommended limits for public supply. For some time, the city has been considering various alternatives for improving both the quantity and quality of its water supplies.

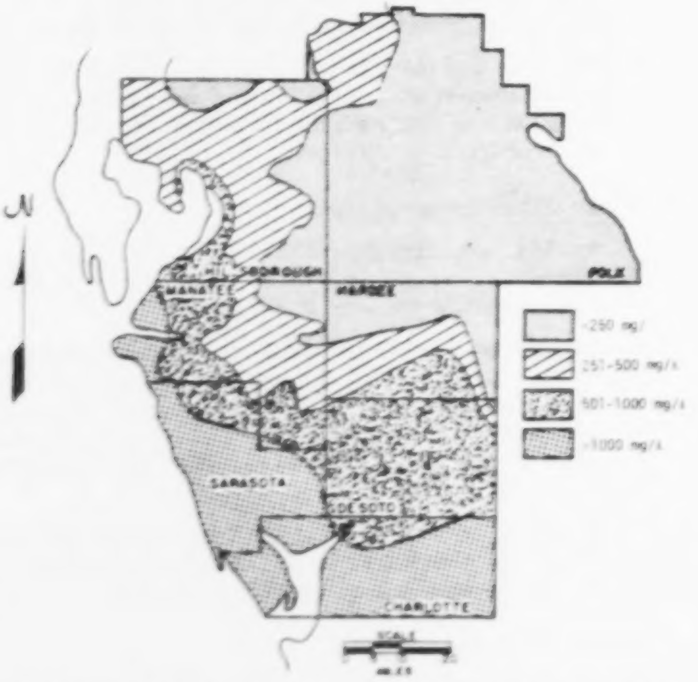

Figure 2.8. Dissolved Solids in Water from Upper Part of Floridan Aquifer (Shampine 1964c)

There is also concern about the radiation environment in Florida, particularly in relation to groundwater contamination. Ra 226 concentrations in shallow aquifers in central Florida mining and processing areas in 1966 and 1973 were as high as 76 picocuries per liter, while the USPHS recommended limit in drinking water is 3 picocuries per liter. An EPA investigation in 1977 assessed radiation levels due to radium in nonmineralized areas (those not containing marketable phosphate matrix reserves), mineralized but umined areas (those having marketable phosphate matrix not yet mined), and mineralized, mined areas (those having marketable phosphate matrix being mined) in the 7-county study area. The study considered two subareas: (1) Polk, Hardee, Hillsborough, DeSoto, and Manatee counties; and (2) Sarasota County. Study-area 1 displayed the following:

- Water-table aquifer
  - The geometric mean of radium concentration in unmined mineralized areas was 0.17 picocuries per liter; in mined areas, 0.55 picocuries per liter.
  - Dissolved radium (Ra-226) assessment by Mann-Whitney U-test ($\alpha = 0.05$) indicated no significant difference between areas impacted by mining and mineralized but unmined areas.
  - None of the Ra-226 concentrations in mined areas exceeded 5 picocuries per liter (the EPA regulation for combined Ra-226 and Ra-228 concentration).
- Upper Floridan aquifer
  - Ra-226 concentrations averaged as high or higher in nonmineralized areas as in mineralized unmined or mined areas.
  - Dissolved Ra-226 assessment by the Kruskal-Wallis test ($\alpha = 0.05$) indicated significant differences between nonmineralized, mineralized unmined, and mined areas; and the nonmineralized areas displayed higher Ra-226 concentrations than the mined areas.
  - Average Ra-226 concentrations were higher than those in the water-table aquifer and similar to those in the lower Floridan aquifer.
- Lower Floridan aquifer
  - Ra-226 concentrations averaged as high or higher in nonmineralized areas as in mineralized unmined or mined areas.

- Ra-226 concentrations were not significantly different (Mann-Whitney U-test, $\alpha = 0.05$) in nonmineralized and mineralized unmined and mined areas.

Study-area 2 displayed the following:

- Ra-226 concentrations were 100 times higher in the water-table aquifer and almost 10 times higher in the upper and lower Floridan aquifers than in study area 1.
- Ra-226 concentrations in the water-table aquifer in the coastal area were significantly greater (Mann-Whitney U-test, $\alpha = 0.05$) than in the inland area.
- Higher-than-average (relative to Florida and U.S.) Ra-226 concentrations in both the water-table and Floridan aquifers are attributed to natural enrichment (probably related to radium-enriched, mineralized ground water that is deep beneath the central Florida peninsula and shallow in the coastal areas) and to dissolution of Ra-226 from the Hawthorn formation (which is very near the land surface in western Sarasota County).

As far as the entire 7-county study area is concerned:

- A detrimental effect by phosphate mining on Ra-226 in the upper Floridan aquifer is not documented. Existing radium data do not substantiate previously alleged widespread radium contamination of ground water by the phosphate industry. Natural variability in the radium content of ground water complicates determination of background versus contaminated conditions and underscores the need for more intensive data collection as an integral part of water and land management.

- Ra-226 data collected from the water-table, upper Floridan, and lower Floridan aquifers in 1966 by the Federal Water Pollution Control Administration and in 1974-76 by the United States Geological Survey revealed no statistically significant (Kruskal-Wallis test, $\alpha = 0.05$) difference for the decade interval (1966-76).

- Hydrogeologic conditions favor entrance of contaminants to at least the water-table and upper Floridan aquifers, but contamination is generally poorly documented due in part to monitoring deficiencies. Potential contaminant sources include high dissolved radium in gypsum-pond water and suspended radium in slime ponds. Contaminants can enter ground water because of sinkhole collapse (or similar release) and seepage; especially does the siting of waste-disposal facilities in contact with limestone strata of the Hawthorn formation foster contamination. Incidence of local contamination (laterally to distances of a mile or less and to depths of several hundred feet or less) is likely to continue as water use and mining expand. Additional industry-sponsored monitoring of shallow aquifers is warranted - particularly industry participation in cooperative state and federal studies of long-term water quality changes in the lower Floridan aquifer as a result of water withdrawal and dewatering.

- Hydrogeologic conditions in the area of phosphate mineralization are quite variable (principally in the distribution and permeability of carbonate strata in the Hawthorn formation and the degree of interconnection between the upper and lower Floridan aquifers) and can be favorable or unfavorable for waste disposal. Disposal of acidic chemical processing effluent may induce solution and collapse of carbonate strata and thereby increase contamination, but the data to support the widespread occurrence of this phenomenon are scanty and the environmental impact of the industry needs additional definition via specific studies.

- The radiochemical quality of water introduced to the lower Floridan aquifer via recharge wells has only recently begun to be documented. Preliminary data from the SWFWMD indicate that radium-226 levels are generally lower than those in the lower Floridan aquifer. The occurrence of at least locally high natural concentrations of radium in the shallower aquifers requires close monitoring and site-specific documentation.

2. Water Quality by County

a. Hardee and DeSoto Counties (Wilson 1977)

The water-table aquifer in Hardee and DeSoto counties is tapped at a depth of 40 to 65 feet and is generally believed to increase in thickness from north to south. Many of the wells used for domestic purposes or for lawn-watering or stock-watering tap the water-table aquifer.

The most productive and widely used aquifer in the two counties is the Floridan aquifer. It provides the public water supply for the city of Arcadia.

Within the Floridan aquifer, dissolved-solids concentrations generally increase from northern Hardee County toward southern DeSoto County and also increase with depth. Concentrations exceeding 500 milligrams per liter occur in the upper part of the aquifer in southeastern and southwestern DeSoto County, in the lower Floridan aquifer, along the Peace River, in the southern part of Hardee County, and in all of DeSoto County. The water temperature generally increases from northern Hardee to southwestern DeSoto County, as well as with depth. The water underlying Hardee and DeSoto counties is generally hard because of the predominance of calcium- and magnesium-rich limestone and dolomite in the matrix. Generally, water from the upper part of the Floridan aquifer is moderately hard to hard (61 to 180 milligrams per liter) in northern Hardee County, increasing in hardness toward southern DeSoto County where the water is very hard (exceeding 500 milligrams per liter). Within the lower part of the Floridan aquifer, the only moderately hard to hard water occurs in the northeast corner of Hardee County, with hardness increasing toward the southwest.

Sulfate concentrations in Hardee and DeSoto counties generally increase with depth. Most is probably derived from the solution of gypsum and anhydrite (calcium-sulfate minerals) found in the lower Floridan aquifer. In the upper Floridan, concentrations generally increase from north Hardee to southwest DeSoto. Southwest of Arcadia, concentrations range from 100 to more than 250 milligrams per liter. Only in the northern half of Hardee County does water from the lower Floridan contain less than 100 milligrams per liter of sulfate. A zone exhibiting more than 250 milligrams per liter extends across southernmost Hardee County, northern DeSoto County, and southward along the Peace River valley, with the water in most of southern DeSoto County containing less sulfate (101-250 milligrams per liter).

Chloride concentrations in the Floridan aquifer in Hardee and DeSoto counties generally are less than 50 milligrams per liter although in areas south of Arcadia they range from 50 to 250 milligrams per liter and near the southwest Sarasota-DeSoto county line exceed 250 milligrams per liter. Concentrations of fluoride in the Floridan aquifer underlying the two counties form a concentric pattern, increasing toward the center. In both the upper and lower Floridan aquifers, concentrations are 0.8 milligrams per liter or less only along the periphery of Hardee and DeSoto counties (except along the western boundary where concentrations are higher). In much of the central area along the Hardee-DeSoto county line, aquifer concentrations in the upper Floridan exceed 1.4 milligrams per liter (and some exceed 2.0 milligrams per liter). In the lower Floridan, concentrations exceeding 1.4 milligrams per liter are restricted to western DeSoto County. The principal source of fluoride in Hardee and DeSoto counties is fluorapatite, a mineral restricted to rocks of the upper Floridan aquifer and younger deposits. Fluorapatite is the principal source mineral of phosphate in the land-pebble mining district of central Florida.

b. Charlotte County

In 1975, a study of the water resources of Charlotte County was initiated (Sutcliffe 1973) because the county was beginning to experience major problems in obtaining sufficient water of suitable quality to meet public demand. For the study, the county was partitioned into four zones.

In Area A in the county's western peninsula, the water-table aquifer is the only source of fresh water and is subject to contamination by salt water from the Gulf during exceptionally high storm tides; in places, chloride concentrations may be as high as 12,000 milligrams per liter. Canalization of some of the low-lying land of the peninsula also has promoted saltwater contamination. Well pumping in this area is restricted to approximately 20 gallons per minute so excessive drawdowns will not produce encroachment of underlying salt water. In the artesian aquifers of this area are large quantities of saline water. Concentrations of dissolved solids (5,000 to 9,000 milligrams per liter from less than 350-foot depths) appear to decrease from south to north. Since pressure in the artesian aquifer is higher in deeper zones than in shallow zones, multiple-zone wells cause the more saline water of the deeper aquifers to deteriorate the quality of water in the shallower zones. Also, as the more saline water discharges at the surface, the water-table quality tends to deteriorate.

Area B, the most urbanized area of Charlotte County, lies between the Myakka and Peace rivers. The quality of the water in the water-table aquifer is generally good, but the water is not commonly used as a supply because of persistently high iron and color concentrations. Dredging canals for urban development has caused some saltwater intrusion. The artesian aquifer in area B at a depth of 70 feet has a chloride content that exceeds state limits for public water supply and is marginal for irrigation. The area's most heavily pumped aquifer is at a depth of 115 to 155 feet, and the water is generally suitable for irrigation but not for drinking. Generally in area B, a well that is tightly cased to approximately 150 feet and penetrates to less than 230 feet can produce water with a dissolved-solids content of less than 1,000 milligrams per liter. Water from a deeper zone (about 250-400 feet) has a higher dissolved-solids concentration (approximately 2,000 milligrams per liter), as well as higher chloride and sulfate concentrations, than do the shallower zones. The water pressure in the lower zone is higher than in shallower zones, so older wells where the casing is damaged may cause water from the deeper zones to contaminate the overlying aquifers and even the water-table aquifer.

Area C is in the central part of Charlotte County and is bordered on its western edge by Charlotte Harbor. This highly urbanized coastal area experiences problems in obtaining public-supply water of good quality from ground water. The water-table aquifer is used extensively for some domestic and irrigation supplies. While most of the shallow wells produce drinking water meeting state standards, many produce water containing more than 2 milligrams per liter of iron. Wells penetrating this aquifer near Charlotte Harbor or into fill overlying former saltwater marshes produce water with a chloride content exceeding 250 milligrams per liter. Some salt water has migrated into the aquifer in inland areas from free-flowing wells that tap artesian aquifers containing saline water. Many of the wells that originally tapped the artesian aquifers have been abandoned, improperly plugged, and buried and now act as conduits, allowing saline water from deeper zones to contaminate the shallow artesian and water-table aquifers. The artesian aquifer at a depth of 50 to 150 feet is the most heavily pumped aquifer in area C for domestic purposes and irrigation. In the western half of area C, the water generally exceeds the state's drinking-water standards because of high chloride and dissolved-solids concentrations; in the eastern half of area C, however, the water meets the state's drinking-water standards. Water from deeper zones (between 150 and 900 feet) generally is suitable for irrigation but not for drinking. Chloride content generally increases from north to south, and sulfate content increases with depth. Leaky wells that penetrate this zone but were capped during urbanization of the area allow water of poor quality to move up the old bores into shallower aquifers.

Area D is the sparsely populated area surrounding Telegraph Swamp. The water-table aquifer in this area has the potential to yield large quantities of water for public supply to Charlotte County. Wells that are less than 40 feet deep yield water that is low in chloride and sulfate. The artesian aquifers to a depth of approximately 300 feet generally contain water that meets the state drinking-water standard. Concentrations of dissolved solids, chloride, and sulfate generally increase with depth.

c. Sarasota County (Southwest Florida Regional Planning Council 1976)

Artesian waters of Sarasota County are mineralized in the northwest. Mineralization generally increases to the south and with depth. The Avon Park aquifer is too highly mineralized beyond 800 feet to be considered a probable source of water supply. In the northeastern portion of the county, the water is potable at a depth of 600 to 800 feet. At 300 to 450 feet in the northern half of the county is an artesian aquifer that is a potable water source. In some areas of the middle and southern parts of the county, however, the water is too highly mineralized to be potable.

The Hawthorn formation (at a depth of 150-300 feet) is an important source of water in Sarasota County, and most of the water in this formation is under artesian pressure. The Hawthorn formation contains saline water at depths of 60 to 100 feet in some areas along the coast but shows relatively little mineralization in most inland areas. South of Nakomis, chloride concentrations in the artesian portion of the Hawthorn formation may be 250-3,500 milligrams per liter. Except for coastal areas where abandoned, free-flowing, deep, saline wells and the lowering of waterways have caused saltwater contamination, the water-table aquifer (surface to 25 feet) displays the least mineralization of the county ground waters. In the Port Charlotte area, local water-table pollution has been related to seepage from septic tanks and to runoff and infiltration of pesticides and fertilizers.

d. Hillsborough County (Southwest Florida Water Management District 1975)

Data on the quality of water from the water-table aquifer (6-35 feet) in Hillsborough County are sparse but generally indicate the following:

Parameter	Concentration
Chloride	42-130 mg/l
Hardness	21-130 mg/l
Conductivity	269-2,530 μmhos
Total dissolved solids	160-1,973 mg/l

Water from the aquifer generally is used for domestic and small-scale irrigation requiring less than 100 gallons per minute.

Data from the Hawthorn formation (depths of 20-105 feet) display the following ranges:

Parameter	Concentration
Chloride	5-110 mg/l
Hardness	0-280 mg/l
Conductivity	128-1,100 μmhos
Total dissolved solids	80-850 mg/l

This aquifer is of little importance in Hillsborough County.

In the Floridan aquifer in Hillsborough County, the following ranges are generally found:

Parameter	Concentration	Median
Chloride	1-3,300 mg/l	20 mg/l
Sulfate	0-990 mg/l	235 mg/l
Hardness	150-2,100 mg/l	450 mg/l
Total dissolved solids	190-8,500 mg/l	605 mg/l

Toler (1967), in mapping the distribution of fluoride in ground water in the Alafia and Peace River basins, found that fluoride occurs naturally in ground water at concentrations of 0.0-4.0 milligrams per liter. Toler also found evidence of contamination of shallow aquifers by deeper aquifers as a result of interconnections among the various aquifers, particularly in the coastal agricultural zone from Riverview south to beyond Ruskin. Numerous large, deep irrigation wells, some of which have flowed continuously since being drilled many years ago, have contaminated the area with salty, sulfur water.

Hillsborough County has experienced entrance of contaminants to the ground water through sinkholes. In 1974, a sinkhole that opened up in the bottom of Lake Grady drained lake water into the underlying aquifer. Approximately 12 domestic supply wells in a neighborhood east of the lake were bacterially contaminated and contained foreign matter similar to that found in the lake.

e. Manatee County (Peek 1958)

Manatee County obtains small supplies of ground water from the water-table aquifer but most domestic water from the upper part of the Hawthorn formation. The Suwannee and Tampa formations of the Floridan aquifer are the principal sources of ground water.

Chloride concentrations exceed 2,000 milligrams per liter in some places in the Suwannee limestone but are generally less than 500 milligrams per liter. The lowering of the peizometric surface since 1948 has increased the chloride content in an area 4-16.1 kilometers (3-10 miles) wide along the coast-and the degree of contamination increases with depth and proximity to the coast.

A large portion of Manatee County is used for growing winter vegetables and citrus, and much artesian water is used for irrigating these crops. This considerably decreases the artesian head, which in turn increases the possibility of saltwater encroachment.

In the groundwater aquifers underlying Manatee County, concentrations of calcium, magnesium, sodium and potassium, sulfate, chloride, and total dissolved solids increase with depth. Water in the Floridan aquifer in most of the county contains chloride concentrations of 25 milligrams per liter or less; the exception is along the coast where concentrations are generally 50-500 milligrams per liter. Hardness is greatest in a band along the coast, with concentrations ranging from 750 to more than 1,000 milligrams per liter. Hardness is 250 milligrams per liter or less in most of the headwaters of the Little Manatee, Manatee, and Myakka rivers.

f. Polk County

Most of the wells in Polk County withdraw water from the Floridan aquifer, seldom using water from the Hawthorn formation because of its high mineral and clay content and its pollution. A few small domestic wells and some local irrigation are supplied from the water-table aquifer, the quality of which is greatly affected by local land use and is locally degraded by agricultural activities. Table 2.13 compares the water quality in the various aquifers underlying Polk County. There are no general pattterns of change with respect to depth.

Because of solutional removal of limestone by circulating ground waters, the limestone material in the groundwater aquifers underlying Polk County have many interconnected openings, the sizes of which range from a

Table 2.13. Range of Concentration of Chemical Constituents in Waters of Polk County*

	Range in Parts per Million				
Constituent	Surface water	Nonartesian Aquifer	Uppermost Artesian Aquifer	Secondary Artesian Aquifer	Floridan Aquifer
Temperature (°F)	63-83	72-76	73-74	72-82	72-82
pH (pH unit)	4.5-7.7	4.9-7.6	6.5-7.7	7.4-8.0	6.7-8.1
Hardness (mg/l)	8-190	3-450	215-232	47-308	40-372
Dissolved solids (mg/l)	55-224	29-715	214-334	115-361	42-383
Specific conductance (µmho/cm)	33-381	36-2,477	385-727	174-734	113-594
Silica (mg/l)	1.7-17	-- 9	--	12-27	7.1-22
Total iron (mg/l)	0.20-0.74	0.4-.93	--	0.02-0.23	0.00-2.7
Calcium (mg/l)	1-49	1-137	-- 40	38-69	15-127
Magnesium (mg/l)	1.2-16	1-15	-- 22	0.4-31	0.4-29
Sodium (mg/l)	3-8.4	1.5-6.4	-- 8.9	3.2-11	1.5-23
Potassium (mg/l)	0.1-2.7	0-2	--	0.3-5.0	0.3-4.6
Bicarbonate (mg/l)	3-218	1-206	-- 192	9-237	22-250
Sulfate (mg/l)	3.2-49	0-22	1.5	0.6-91	0.3-322
Chloride (mg/l)	5.2-16	2.5-20	8.1	6-28	4-22
Fluoride (mg/l)	0.1-1	--		0.5-6.0	0.0-1.8
Nitrate (mg/l)	0.0-1.5	0.2-0.9		0.0-2.4	0.0-4.9
Phosphate (mg/l)	0.0-0.30	0.00-0.96	-- 0.11	0.00-2.1	0.00-5.3
No. of samples	10	9	2	26	108 (from 77 wells)

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*Stewart (1966)

few centimeters (fraction of an inch) to a few meters (many feet). Although limestone is only slightly soluble in pure water, slightly acid water dissolves limestone much more readily. Rainwater absorbs carbon dioxide from the atmosphere and forms carbonic acid; as the water percolates through the soils, it combines with more carbon dioxide. When this slightly acidic water comes into contact with the limestone material of the aquifers, dissolution occurs. Two factors that appear to primarily influence the amount and rate of solution are the amount of contact area and the length of time in which the water and limestone are in contact (Stewart 1966). Solution of limestone is particularly facilitated along fractures, joints, and bedding planes that exist in the underground rock formations. As solutional caverns become larger, the roofs may not be able to support the overlying materials and may collapse, producing sinkholes. Between 1953 and 1960 in westcentral Florida, 30 active sinkholes were reported; 19 were in Polk County (Stewart 1966). During a 3-week period after a sinkhole opened under a waste-gypsum stockpile near Mulberry in early 1975 (Miller et al 1977), 17 million liters of gypsum leachings (with a radium-226 value of 91 picocuries per liter) and 68,800 cubic meters of solid gypsum (23 picocuries per gram) entered the ground water through the sinkhole. Although the pH of the liquid effluent was less than 2.0, piezometers around the stockpile yielded water having a pH exceeding 7.0. This phenomenon and the sudden collapse were explained by the discovery that the site was highly fractured and subject to sinkhole formation. Inspection of aerial photographs taken before the site was used for waste-gypsum stockpiling revealed that the area is cut by many long lineations representing fractures extending to land surface. The collapse occurred at the intersection of two of these lineations. Prior to collapse, the acidic leachings from the stockpile enlarged the fractures, permitting more rapid downward movement of contaminant fluids and eventually structural weakening of the area. There was essentially no lateral movement of the radioactive acidic solutions.

Lakes are abundant in Polk County. Some are relatively independent of the effect of artesian pressures because of the presence of underlying sediments that restrict the upward or downward movement of water; others are connected directly to the underlying artesian Floridan aquifer so that their levels fluctuate directly with changes in the piezometric surface except during periods of surface flow. Contaminants entering the lakes have the potential for downward movement into the artesian aquifer if there are sufficient head differences to cause lake-bottom collapse or direct movement of contaminants into the aquifer due to recharge from the lakes. The depth of Lake Parker in northwest Polk County has experienced large fluctuations, which have been correlated with withdrawals from ground water in areas surrounding the lake. Stewart (1966) concludes that the future withdrawal of ground water from mine pits in the nonartesian aquifer south of State Highway 33 and north and northeast of Lake Parker may tend to lower the level of the lake by (1) reducing groundwater inflow into the lake by interception and (2) by inducing groundwater outflow from the lake through the nonartesian aquifer toward areas in which the water table is drawn down to especially low levels. Withdrawing water from the artesian aquifers near Lake Parker would lower the piezometric surface and increase the vertical hydraulic gradient under the lake, increasing the rate of leakage from the lake to the aquifer (Stewart 1966).

3. Outlook

The future of groundwater within the 7-county study area is difficult to predict because the groundwater hydrology of the area and the effects of future waste-disposal techniques are not completely understood. As the number of deep injection wells for underground storage of industrial and municipal wastes increases as an alternative means of waste disposal that eliminates discharge directly to surface waters, the potential for progressively decreasing groundwater quality increases, especially if the waste concentrations being injected into the groundwater systems are not monitored properly.

Drainage wells pose a particular threat to groundwater quality in Florida; more than 6,500 such wells are known to exist and to receive water ranging from normal surplus water to considerably polluted urban storm runoff as well as sewage, agricultural, and industrial fluid wastes (Miller et al 1977). Flowing freshwater and saltwater wells that cause gradual saltwater encroachment and contamination of surficial and confined aquifers will continue to be a problem until all such wells are properly plugged. It is estimated that in Florida alone there are 2,000 to 3,000 flowing wells producing water of poor quality (Miller et al 1977).

Groundwater contamination has probably occurred on a local level in the phosphate mining area of Florida (Miller et al 1977). As mining activities expand in Florida, more contamination may occur. At the moment, however, documentation of groundwater contamination from phosphate industry activities is not sufficient to draw firm conclusions or make precise predictions.

SECTION 3

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CHAPTER 2

AQUATIC BIOTA

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SECTION 1

INTRODUCTION

The biota of the fresh, brackish, and marine waters of the study area (Hillsborough, Charlotte, Manatee, Hardee, Polk, Sarasota, and DeSoto counties, Florida) represent a valuable resource and, like any other, requires judicious management if its important benefits are to be realized.

The baseline ecological characterizations of the study area's various aquatic communities developed in the following text will provide a basis for projecting environmental impacts that may result from further development of the central Florida phosphate industry and should prove helpful also in arriving at resource management decisions concerning the waters and/or aquatic biota of the 7-county area. The baseline characterizations will be presented by basic community types, i.e.:

- Lentic communities (standing freshwater: lakes, ponds, pits)
- Lotic communities (running freshwater: rivers and streams)
- Estuarine and bay communities

A fourth aquatic community of the study area, the wetlands (swamps, marshes, wet prairies), is considered in depth in Volume VI (Section 5) of this series, so this text will treat it as an adjunct to the three basic community types. Where feasible, occurrences and relative abundances of organisms reported in the study area's various communities will be tabulated. The richness and unique diversity of the aquatic biota of the study area will be evident in these lists and generally will indicate influences of a mild climate and fertile waters.

Following the basic characterizations of the three major community types, the text will deal specifically with threatened and endangered species, species of commercial and recreational importance, nuisance and pest species, and resource management within the 7-county study area.

SECTION 2

AQUATIC COMMUNITIES

A. LENTIC COMMUNITIES

The lentic, or standing freshwater, communities comprise natural and man-made lakes and impoundments, ponds, pits, and seasonally wet depressions. Despite an abundance of lentic waters in the study area (major water bodies are shown on Plate 5 in pocket), there is a paucity of available information on their ecological characteristics. Because of relatively uniform environmental influences throughout the study area, however, biotic composition and abundance patterns reported in certain water bodies are likely representative of those within water bodies of similar character.

Many smaller lentic water bodies in the study area are intermittent generally becoming dry during early spring. These water bodies support transitional communities only part of the year or, in a few areas, only during years of adequate rainfall. The majority of the larger water bodies, however, have permanent water; they are naturally shallow (average depth of less than 6.2 meters, or 20 feet), have sloping sides with wide littoral zones, and maintain moderate to luxuriant algal and vascular plant communities that support comparatively large populations of zooplankters, macroinvertebrates, and fishes. Some of the water bodies that maintain permanent water, particularly those in Hillsborough and Polk counties, are reclaimed or unreclaimed mining areas; these lakes have been allowed to naturally revegetate and colonize with faunal species or have been transformed into recreational impoundments. Such water bodies generally have steeply graded sides and narrow littoral zones of comparatively low diversity; a high phosphate content, however, makes them quite productive and hastens eutrophication.

A number of exotic species, primarily introduced tropical forms, reside in lentic waters of the study area. Most were intentionally introduced as game species or biological control agents although some were accidentally released, especially from poorly managed or improperly designed fish farms. A few exotics have become disruptive elements in the community; others have become stabilized and add to the unique variety of species found in the study area.

1. Flora

a. Algae

The algae of lentic freshwater communities comprise three basic community types: phytoplankton, the assemblage of microscopic algae that drift with currents in the water column; tychoplankton, the assemblage of algae found growing among the vegetation along the shores of lakes and ponds; and periphyton, the algae that grow attached to submerged objects such as rocks and limbs. Algae are, along with aquatic vascular plants, producers of organic materials in the community.

Details on the lentic algae in the study area appear limited to a limnological investigation of Lake Thonotosassa in Hillsborough County (Cowell et al 1975) and a study of several ponds and temporary pools in northern DeSoto County (TI 1977). Occurrences and relative abundances of algae reported during the studies appear in Table 2.1.

High standing crops of phytoplankton occurred throughout the year in Lake Thonotosassa (Cowell et al 1975), with September exhibiting the peak and January the minimum. Mean monthly biovolumes ranged from 2.26 to 14.72 microliters per liter (6 to 107 x 10^3 cells, filaments and/or colonies per milliliter), with an annual mean of 5.78 microliters per liter (Table 2.2). Only 47 phytoplankton species were found regularly in the lake; more were undoubtedly present, but biovolume was obtained with a volumetric counting technique that precluded determination of the total number of species.

Diatoms were volumetrically dominant during winter and early spring (Cowell et al 1975); in summer, however, populations were generally low. The most common diatoms were *Melosira granulata* (81 percent of the annual mean volume), *Stephanodiscus hanzschii*, and *Cyclotella stelligera*.

Table 2.1. Occurrences and Relative Abundances of Algae in Lake Thonotosassa and Temporary Pools and Ponds of DeSoto County

Lentic Algae	Lake Thonotosassa of Hillsborough County	Temporary Pools & Ponds of DeSoto County
Cyanophyta		
Oscillatoria	A	C
Anabaena	A	O
Agmenellum	C	C
Lyngbya	-	C
Anacystis	C	-
Spirulina	C	-
Aphanocpsa	C	-
Microcystis	-	O
Entophyealis	-	U
Pleurocapsaceae (unspecified)	-	U
Calothrix	-	R
Chroococus	-	R
Chlorophyta		
Scenedesmus	C	A
Ankistrodesmus	-	A
Chlamydomonas	-	A
Pediastrum	C	O
Tetraedron	C	R
Spermatozoopsis	-	C
Crucigenia	-	C
Chaetophorales (unspecified)	-	C
Oedogonium	-	C
Movgeotia	-	C
Eudorina	-	O
Gleocystis	-	O
Kirschneriella	-	O
Oocystis	-	O
Tetrastrum	-	O
Clostarium	-	O
Desmidium	-	O
Staurastrum	-	O
Pleurotaenium	-	O
Bulbochaete	-	O
Penium	-	O
Micrasterias	-	O
Closteriopsis	-	U
Dictyosphaerium	-	U
Cosmarium	-	U
Euastrum	-	U
Geminella	-	U
Carteria	-	R
Panderina	-	R
Pedinomonas	-	R
Micractinium	-	R
Shroedaria	-	R
Coelastrum	-	R
Chodatella	-	R
Nephrocytium	-	R
Dactylococcus	-	R
Raysiella	-	R
Ulotrichales (unspecified)	-	R
Aphanochaete	-	R
Spirogyra	-	R

A = Abundant
C = Common
O = Occasional occurrences
U = Uncommon
R = Rare
P = Present, but with no indication of abundance

Table 2.1 (Contd)

Lentic Algae	Lake Thonotosassa of Hillsborough County	Temporary Pools & Ponds of DeSoto County
Hyalotheca	-	R
Tetmemorus	-	R
Radiofilum	-	R
Tetraspora	-	R
Elakatothrix	-	R
Sphaerocystis	-	R
Spondylosium	-	R
Arthrodesmus	-	R
Xanthidium	-	R
Gonatozygon	-	R
Triploceras	-	R
Bambusina	-	R
Zygnema	-	R
Actinastrum	C	-
Euglenophyta		
Euglena	C	C
Trachalomonas	-	C
Lepocinclis	-	O
Phacus	-	U
Xanthophyta		
Stipitococcus	-	O
Tribonema	-	R
Chrysophyta		
Mallomonas	-	O
Dinobryon	-	O
Chrysomonadales (unspecified)	-	O
Rhizochrysidales (unspecified)	-	O
Chrysococcus	-	U
Ochromonas	-	U
Derepyxis	-	U
Stylobryon	-	R
Lagynion	-	R
Kybotion	-	R
Bacillariophyta		
Melosira	A	C
Nitzchia	-	A
Enotia	-	A
Cyclotella	C	C
Fragilaria	C	O
Stephanodiscus	C	R
Frustulia	-	C
Achnanthes	-	C
Navicula	-	C
Pinnularia	-	C
Opephora	-	O
Synedra	-	O
Desmogonium	-	O
Cocconeis	-	O
Neidium	-	O
Gomphonema	-	O
Amphora	-	O
Cymbella	-	U
Caloneis	-	U
Diatoma	-	R
Skeletonema	-	R
Thalassiosira	-	R
Rhizosolenia	-	R
Anomoneis	-	R
Pleurosigma	-	R
Mastogloia	-	R
Stauroneis	-	R
Amphiprora	-	R
Bacillaria	-	R
Pyrrophyta		
Gymnodinium	-	C
Peridinium	-	C
Gonyaulax	-	C
Gymnodiniales (unspecified)	-	C
Ceratium	U	-
Glenodinium	U	-
Cryptophyta		
Cryptomonadales (unspecified)	-	A
Cryptomonas	C	A
Rhodomonas	-	A

Table 2.2. Mean Biovolume and Percent Contribution of Major Groups of Algae to Total Phytoplankton Standing Crop in Lake Thonotosassa, Florida, February 1970-January 1971*

Month	Mean Biovolume[†] and Percent Contribution (in parentheses) in Surface Samples					
	Diatoms	Green Algae	Bluegreen Algae	Cryptophytes	Dinoflagellates	Monthly Mean Biovolume
Feb	4.16 (60.7)	0.84 (12.2)	-	1.86 (27.1)	-	6.86
Mar	2.78 (52.0)	2.12 (39.6)	-	0.36 (6.7)	0.09 (1.7)	5.35
Apr	2.38 (44.1)	1.77 (32.8)	0.12 (2.2)	0.49 (9.1)	0.64 (11.8)	5.40
May	2.62 (39.4)	3.08 (46.3)	0.60 (9.0)	0.01 (0.2)	0.34 (5.1)	6.65
Jun	0.36 (7.8)	1.88 (40.9)	1.66 (36.1)	0.52 (11.3)	0.18 (3.9)	4.60
Jul	0.84 (12.8)	1.19 (18.1)	4.50 (68.6)	0.02 (0.3)	0.01 (0.2)	6.56
Aug	0.38 (4.2)	0.46 (5.1)	8.06 (89.8)	0.08 (0.9)	-	8.98
Sep	0.45 (3.1)	0.40 (2.7)	13.34 (90.6)	0.06 (0.4)	0.47 (3.2)	14.72
Oct	0.78 (18.3)	1.08 (25.3)	1.17 (27.4)	1.24 (29.0)	-	4.27
Nov	1.12 (38.2)	0.86 (29.4)	0.15 (5.1)	0.80 (27.3)	-	2.93
Dec	0.98 (38.1)	0.87 (33.9)	-	0.48 (18.7)	0.24 (9.3)	2.57
Jan	1.06 (46.9)	0.86 (38.0)	-	0.34 (15.1)	-	2.26
Annual Mean	1.45 (24.7)	1.27 (21.6)	2.49 (42.5)	0.50 (8.5)	0.16 (2.7)	5.87

*Cowell, Dye and Adams (1975)

[†]Reported as microliters per liter (μℓ/ℓ)

From three to nine species of green algae were recorded during each sampling period, with volumetric dominance often changing from one period to another. They were more abundant in spring and early summer and were the dominant phytoplankton group in May and June. A summer bloom of bluegreen algae comprised principally *Anabaena spiroides* and *Oscillatoria* spp. The cryptophyte algae, represented by a single species of *Cryptomonas*, peaked in February and October, comprising almost 30 percent of the total phytoplankton biovolume during those months.

Both phytoplankton and periphyton communities were examined in the small waterbodies in northern DeSoto County (TI 1977). Periphyton removed from a variety of substrates during March, May, and August yielded 106 taxa, 55 of which were green algae, 27 were diatoms, and 13 were bluegreens. Taxa common to all three seasons were *Oscillatoria*. *Lyngbya*, *Scenedesmus*, *Oedogonium*, *Mougeotia*, *Closterium*, *Cosmarium*, *Euglena*, *Trachelomonas*, *Melosira*, *Fragilaria*, *Eunotia*, and *Nitzchia*. Green algae generally dominated each season: principally, *Oedogonium* and *Mougeotia* in March, *Oedogonium* and *Scenedesmus* in May, and *Oedogonium* and *Spirogyra* in August. The diatom *Frustulia* also was prevalent in August.

Phytoplankton from the small DeSoto County waterbodies was dominated in biovolume by greens, chrysophytes, and dinoflagellates and in density by greens and bluegreens (TI 1977). The most common taxa were *Oedogonium, Closterium, Ankistrodesmus, Mougeotia, Dinobryon, Peridinium, Gymnodinium,* and *Gonyaulax.* Euglenoids such as *Euglena* were particularly abundant in pools of small intermittent drainage courses having high organic content.

In a shoreline survey of the vegetation of man-made lakes in Sarasota County (Folit et al 1975), only two of 100 lakes showed evidence of nuisance growths of *Anabaena*, while four contained visible growths of *Microcystis*. Less than 25 percent of the surface area of each lake was covered by slimes formed by these algae. Dense growths of the green macroalgae *Chara* were noted in two of the lakes studied, while dense, filamentous mats of *Oedogonium, Spirogyra,* and *Pithophora* were observed along the shores of several other lakes.

During a March 1977 field reconnaissance of lakes and ponds in the 7-county study area (particularly Polk and Hillsborough counties), TI found no evidence of significant nuisance conditions caused by overabundances of filamentous algae.

b. Vascular Plants

Aquatic macrophytes are an important and highly visible component of lentic habitats of the study area: besides producing organic materials, they provide habitat or cover for animal communities, and help stabilize shorelines. Like algae, however, overabundances can cause severe nuisance problems in standing water bodies. One rather fortuitous benefit of aquatic vascular plants is their rapid invasion of slime ponds associated with phosphate mining: cattails invade the rather sterile ponds, stabilizing the slime with their root systems and accelerating dewatering and accretion of the slime through increased evapotranspiration.

Aquatic vasculars and the counties of the study area in which they were recorded are listed in Table 2.3. In addition to the sources indicated on the table, results of TI's March 1977 field reconnaissance are included.

Table 2.3. Occurrences of Aquatic Vascular Plants in Lentic Habitats within Counties of Study Area*

Lentic Aquatic Vascular Plants	Polk	Hillsborough	Hardee	Manatee	DeSoto	Sarasota	Charlotte
Water hyacinth *(Eichhornia crassipes)*	X	X	NO DATA	X	X	X	-
Hydrilla *(Hydrilla verticallata)*	-	X		X	-	X	-
Coontail *(Ceratophyllum sp.)*	-	X		-	-	-	-
Floating hearts *(Nymphoides aquatica)*	-	-		-	X	-	-
Water grass *(Hydrochloa carolinensis)*	-	X		-	X	-	-
St. John's-wort *(Hypericum myrtifolum)*	-	X		X	X	-	-
Panic grass *(Panicum* spp.*)*	-	X		X	X	X	X
Cattail *(Typha* spp.*)*	X	X		X	X	X	X
Arrowhead *(Sagittaria* spp.*)*	-	-		-	X	X	X
Spike rush *(Eleocharis* spp.*)*	-	X		X	X	X	X
Duckweed *(Lemna* spp.*)*	-	X		X	X	X	-
Pickerel weed *(Pontedaria* spp.*)*	-	X		X	X	X	X
Rush *(Juncus* spp.*)*	-	X		X	X	-	-
Smartweed *(Polygonum* spp.*)*	-	X		X	X	X	-
Water lily (*Nymphaea* spp.)	-	-		-	X	X	-
Spatterdock *(Nuphar* spp.*)*	-	X		X	X	-	-
False loosestrite *(Ludwigia* spp.*)*	-	X		X	X	-	-
Water pennywort *(Hydrocotyl* spp.*)*	-	X		X	X	X	X
Bladderwort *(Utricularia* spp.*)*	-	X		X	X	-	-
Hedge hyssop *(Gratiola* spp.*)*	-	-		-	X	-	-
Water Hyssop *(Bacopa* spp.*)*	-	-		-	X	-	-
Elodea *(Anacharis* sp.*)*	X	-		-	-	-	-
Aquatic moss *(Fissidens* sp.*)*	X	X		X	-	-	-
Water lettuce (*Pistia stratiotes*)	X	X		X	-	X	-
Fanwort *(Cabomba carolinana)*	-	X		X	-	-	-
Strap-shaped duckweed *(Wolffiella* spp.*)*	-	X		X	-	-	-
Parrotfeather *(Myriophyllum brasiliense)*	-	-		-	-	X	-
Water milfoil *(Myriophyllum spicatum)*	-	-		-	-	X	-
Arrow arum *(Peltandra* sp.)	-	-		-	-	X	-
American frog's-bit *(Limnobium spongia)*	-	-		-	-	X	-
Water fern *(Azolla caroliniana)*	-	-		-	-	X	-
Water fern *(Salvinia rotundifolia)*	-	-		-	-	X	-
Swamp fern *(Blenchum serrulatum)*	-	-		-	-	-	X
Cordgrass *(Spartina bakeri)*	-	-		-	-	-	X
Saw grass *(Cladium jamaicensis)*	-	-		-	-	-	-

*Barnett (1972)
Florida Department of Natural Resources (1975)
Folit et al (1975)
W. R. Grace and Co. (1975)
TI (1977)

Some of the more common aquatic macrophytes in lentic waters of the study area are water hyacinth, hydrilla, coontail, panic grass, spike rush, duckweek, water milfoil, pickerel-weed, and water pennywort. Several of the species (e.g., water hyacinth, hydrilla, and watermilfoil) are known to cause nuisance conditions in the study area (discussed in more detail in Section 3).

Obviously, information on lentic aquatic vasculars in the study area is sparse. For instance, no data at all were found for the Hardee County area. When reviewing distribution, therefore, it should be remembered that absence of county records for a given species does not imply that the macrophyte does not occur in that county — only that it has not been reported from lentic habitats in that county. The species listed in Table 2.3 probably occur in various abundances in all of the seven counties of the study area (also see discussion of lotic communities).

2. Fauna

a. Zooplankton

The zooplankton in lentic as well as other aquatic communities is a valuable link in food chains, transferring available energy from the primary trophic levels (phytoplankton, detritus) to the higher consumer levels. Information on zooplankton in lentic waters of the study area is, like that on algae, limited to studies conducted in Hillsborough County (Cowell et al 1975) and in DeSoto County (TI 1977). These studies report the occurrences and relative abundances shown in Table 2.4.

Table 2.4. Occurrences and Relative Abundances of Zooplankton in Lake Thonotosassa and Temporary Ponds and Pools of DeSoto County

Lentic Zooplankton	Lake Thonotosassa of Hillsborough	Temporary Pools and Ponds of DeSoto County
Cnidaria		
Hydra	-	O
Rotifera (unspecified)	O*	O
Anuraeopsis	C	-
Asplanchna	C	-
Brachionus	C	-
Conochiloides	C	-
Filinia	C	-
Hexarthra	C	-
Keratella	C	-
Microcodon	C	-
Polyarthra	C	-
Synchaeta	C	-
Trichocerca	C	-
Conochilus	O	-
Gastropus	O	-
Lecane	O	-
Lepadella	O	-
Monostyla	O	-
Platyias	O	-
Pompholyx	O	-
Nematoda	-	O
Polychaeta (early life stages)	-	U
Oligochaeta		
Naididae (early life stages)	-	U
Gastropoda (early life stages)	-	U
Hydracarina	-	O
Conchostraca		
Lynceus	-	R
Cladocera		
Bosminidae (unspecified)	-	C
Bosmina	A	-
Chydoridae		
Chydorus	O	C
Alona	-	C
Camptocercus	-	[illegible]
Alonella	-	O
Kurzia	-	U
Eurycercus	-	U
Acroperus	-	U
Leydigia	-	[illegible]
Graptoleberis	-	R
Daphnidae		
Daphnia	C	O
Ceriodaphnia	O	[illegible]
Simocephalus	-	[illegible]
Moinadaphnia	-	U
Scapholeberis	-	R
Leptodoridae (unspecified)	-	R
Macrothricidae		
Ilyocryptus	-	C
Macrothrix	O	R
Sididae		
Diaphanosoma	C	[illegible]
Latonopsis	-	[illegible]
Ostracoda	-	C
Copepoda		
Calanoida (unspecified)	C	C
Diaptomus	C	O
[illegible]	-	R
Eurytemora	-	R
Cyclopoida (unspecified)	C	C
Eucyclops	C	O
Cyclops	O	O
Macrocyclops	C	R
Tropocyclops	-	C
Ergasilus	C	-
Mesocyclops	-	O
Paracyclops	-	R
Harpacticoida (unspecified)	-	O

*A = Abundant
C = Common
O = Occasional occurrences
U = Uncommon
R = Rare
P = Present, but with no indication of abundance

Lake Thonotosassa contained 11 species of copepods and cladocerans and 23 species of rotifers (Cowell et al 1975). No spatial differences in taxonomic composition within a given location were apparent, but marked variations occurred for all species from location to location. Numerical differences on individual sampling dates ranged from zero to two orders of magnitude. Rotifers numerically dominated the zooplankton community, comprising more than 90 percent throughout the year and peaking three times — winter, late spring, and late fall; the minimum was recorded in late summer. The copepod population in the lake exhibited typical spring and fall peaks, and the cladocerans had a single spring peak.

Approximately 89 taxa, primarily comprising Copepoda and Cladocera were found in the small waterbodies of DeSoto County (TI 1977). The most common holoplankters (planktonic organisms that spend their entire life cycle suspended in the water column) were the cladocerans *Chydorus*, *Diaphanosoma*, and *Macrothrix*; the copepod *Tropocyclops*; and copepod juveniles. Major representatives of the meroplankton (organisms that periodically enter the water column) were ostracods and midge larvae. Densities of zooplankton were much higher (up to 266,000 per cubic meter) during the dry season of March and May than in the wet season of August (as low as 3945 per cubic meter) because of the dilution effect of increased rainfall.

b. Macroinvertebrates

The macroinvertebrates of lentic communities play a significant role in predator-prey relationships as well as in the degradation and cycling of detrital materials. They are important food items for many species of fish, transferring a considerable amount of energy to higher trophic levels. Like much of the information on other lentic biota of the study area, that on macroinvertebrates emanates mostly from studies in Hillsborough (Holcomb 1967, Wilbur 1971, Cowell et al 1975) and DeSoto counties (TI 1977); however, the macroinvertebrates information from Hillsborough is more abundant than the flora and zooplankton information from that county. Macroinvertebrates found during these studies and their relative abundances are in Table 2.5.

Table 2.5. Occurrences and Relative Abundances of Macroinvertebrates in Lake Thonotosassa and Temporary Ponds and Pools of DeSoto County

Lentic Macroinvertebrates	Lake Thonotosassa of Hillsborough County	Temporary Ponds & Pools of DeSoto County
Platythelminthes		
Turbellaria (unspecified)	C	
Nemertinea		
Oerstedia	-	R
Nematoda (unspecified)	-	O
Annelida		
Oligchaeta (unspecified)	A	A
Nais	-	O
Dero		R
Tubificidae (unspecified)	-	A
Lumbricidae (unspecified)	-	U
Hirudinea (unspecified)	C	C
Helobdella	-	U
Erpobdellidae (unspecified)	-	U
Mollusca		
Gastropoda		
Viviparus	A	-
Helisoma	C	-
Amnicolidae (unspecified)	C	-
Pomacea	C	-
Physidae (unspecified)	C	-
Lymnaeidae (unspecified)	C	-
Planorbidae (unspecified)	C	-
Ancylidae (unspecified)	C	-
Ferrissia	-	R
Physa	-	R
Gyraulus	-	R
Bivalvia		
Unionidae (unspecified)	C	-
Sphaerium	C	-
Elliptio	O	-
Anodonta	O	-
Arthropoda		
Conchostraca		
Lynceus	-	R
Branchiura		
Argulus	-	R
Isopoda		
Asellus	O	-
Amphipoda		
Hyallela	A	-
Gammarus	-	O
Melita	-	R

A = Abundant
C = Common
O = Occasional occurrences
U = Uncommon
R = Rare
P = Present, but with no indication of abundance

Table 2.5 (Contd)

Lentic Macroinvertebrates	Lake Thonotosassa of Hillsborough County	Temporary Ponds & Pools of DeSoto County
Decapoda		
Procambarus	O	-
Astacidae (unspecified)	C	C
Palaemonidae *(Palaemonetes)*	C	-
Acari		
Prostigmata (Hydracarina)	-	C
Ephemeroptera		
Caenis	O	C
Baetis	-	C
Callibaetis	-	C
Tricorythodes	-	U
Brachycercus	-	U
Baetidae (unspecified)	A	-
Odonata		
Anisoptera		
Perithemis	U	C
Pachydiplax	U	C
Erythemis	-	C
Gomphus	-	C
Libellula	-	O
Coryphaesna	-	O
Macromia	-	O
Epicordulia	-	O
Micrathyria	-	U
Erythrodiplax	-	U
Orthemis	U	U
Celthemis	-	U
Aphylla	U	-
Libellulidae (unspecified)	C	-
Gomphidae (unspecified)	C	-
Zygoptera		
Enallagma	U	A
Ischnura	-	A
Nehalennia	-	O
Argia	-	O
Anomalgrion	-	U
Coenagrionidae (unspecified)	C	A
Hemiptera		
Corixidae (unspecified)	-	C
Trichocorixa	-	C
Sigara	-	U
Buenoa	-	U
Plea	-	U
Naucoridae (unspecified)	C	C
Pelocoris	-	
Belostomatidae (unspecified)	C	C
Belostoma	C	C
Nepidae (unspecified)	C	C
Ranatra	C	C
Mesoveliidae (unspecified)	C	U
Mesovelia	-	U
Gerridae (unspecified)	C	-
Coleoptera		
Dytiscidae (unspecified)	C	C
Hydroporus	-	C
Copelatus	-	O
Celina	-	U
Hydrovatus	-	U
Bidessus	-	U
Bidessonotus	-	U

Table 2.5 (Contd)

Lentic Macroinvertebrates	Lake Thonotosassa of Hillsborough County	Temporary Ponds & Pools of DeSoto County
Coptotomus	-	U
Thermonectus	-	U
Cybister	-	U
Hygrotus	-	O
Gyrinus	-	U
Dinuetus	-	C
Hydrophilidae (unspecified)	O	O
Enochrus	U	U
Berosus	U	U
Hydrochus	-	U
Paracymus	-	U
Tropisternus	U	U
Haliplidae (unspecified)	C	C
Peltodytes	U	A
Hydrocanthus	-	C
Suphisellus	-	O
Colpius	-	U
Helodidae (unspecified)	-	C
Chrysomelidae (unspecified)	C	-
Trichoptera		
Cheumatopsyche		
Hydroptilidae (unspecified)	-	U
Limnephilidae (unspecified)	-	O
Oecetis	C	U
Neuroptera		
Corydalus	-	U
Lepidoptera		
Synclita	-	O
Parapoynx	-	O
Diaphania	-	U
Diptera		
Tipulidae (unspecified)	-	U
Chaoborus	A	-
Tabanidae (unspecified)	C	U
Tabanus	-	U
Empididae (unspecified)	-	U
Ceratopogonidae (unspecified)	A	A
Palpomyia	A	-
Chironomidae (unspecified)	A	-
Chironomus	A	-
Glyptotendipes	A	-
Polypedilum	A	-
Criptochironomus	A	-
Coleotanypus	A	-
Goeldichironomus	C	-
Tanytarsus	C	-
Tanypus	C	-
Procladius	C	-
Parachironomus	O	-
Harnischia	O	-
Cricotopus	O	-
Ablabesmyia	O	-
Conchapelopia	O	-
Cladotanytarsus	U	-
Microcricotopuss	U	-
Nanocladius	U	-
Telmatoscopus	U	-

In Hillsborough County's Lake Thonotosassa, oligochaete worms and chironomids (midges) represent about 70 percent and 25 percent, respectively, of the total benthic macroinvertebrate community (Cowell et al 1975). The lake's shallow areas and feeder streams exhibit the greatest diversity. A spatial variability in densities attributable to the depth distribution of oligochaetes is evident. Annual mean densities of worms ranged from 4,624 to 31,243 per square meter in the feeder streams; 2,825 to 3,643 per square meter in the shallow sandy-bottomed near-shore areas; and 246 to 977 per square meter in the deeper areas. Densities of oligochaetes exhibited a marked spring peak in the feeder streams but showed no major fluctuation in the lake.

In Hillsborough County's Trout Lake and Lake Carlton (Holcomb 1967, Wilbur 1971), oligochaetes, chironomids, and phantom midges *(Chaoborus)* were the major benthic invertebrates, and ceratopogonids (biting midges), amphipods (principally *Hyallela*), odonate larvae, mayfly larvae (mostly Baetidae), caddisfly larvae *(Oecetis)*, and snails *(Viviparus* and *Helisoma)* occurred in smaller abundances.

A fisheries management-related investigation of phosphate pits in Hillsborough County found benthic macroinvertebrates to be lower in diversity and abundance beneath hyacinth mats than in areas lacking hyacinth growth; however, productivity in the entire water column associated with hyacinth mats was much greater than that of substrate alone. Root systems of the water hyacinth beds support an abundant community of macroinvertebrates including (in order of abundance) amphipods *(Hyalleia azteca)*, midges, leeches, and flatworms; occurring less frequently are mayfly larvae, odonate larvae, water bugs, ceratopogonids, and snails. Bluegill sunfish were observed consistently utilizing the invertebrate population within the hyacinth mats.

In northern DeSoto County's small, shallow water bodies, tubificid worms and larval insects including ceratopogonids and midges (principally *Tanytarsus* and *Cryptochironomus*) are most common (TI 1977). The relatively low community diversity and low abundance of higher crustaceans and mollusks in the intermittent water bodies probably is related to the highly variable water levels and periodic dryness of the pools.

In general, there is probably a predominance of oligochaete worms and midge larvae in sediments of deeper standing waters throughout the study area. Aquatic macroinvertebrates are probably most diverse in the littoral vegetation of the shoreline in a community dominated by adult and juvenile insects. The root systems of floating macrophytes such as water hyacinth and water lettuce also would support a substantial community of invertebrates dominated by amphipods and midge larvae.

c. Fishes

Approximately 56 species of freshwater fish (excluding introduced tropical forms) inhabit the standing and running waters of the study area. Table 2.6 lists these species and comments on their role or status within the study area. (Although this report assigns various freshwater fish to either lentic or lotic habitat types, it should be pointed out that there is a good deal of interchange of species between the two habitat types during wet periods and that relatively few species are strictly limited to only one habitat type.)

A minimum of 68 species of freshwater (including introduced species) and estuarine fishes inhabit the standing waters of the study area. Their occurrences and relative abundances in the seven counties are given in Table 2.7.

The majority of the native freshwater species belong to a relatively small number of families that include the shiners (Cyprinidae), freshwater catfishes (Ictaluridae), killifishes (Cyprinodontidae), and sunfishes (Centrarchidae). Many of the species within these families exhibit a relatively wide natural distribution within the 7-county area. In a number of instances, local distribution has been increased through stocking introductions. Estuarine species that have been successfully introduced are the temperate basses (Percichthyidae), which include the striped bass *(Morone saxatilis)*, hybrid striped bass, and the sunshine bass or *Morone saxatilis* x *chrysops* [a reciprocal hybrid of the crossing of white bass *(Morone chrysops)* and striped bass]. Florida's Game and Fresh Water Fish Commission has suggested introducing snook, a member of the estuarine family Centropomidae, into highly eutrophic lakes that no longer support largemouth bass (FGFWFC 1975).

Table 2.6. Freshwater Fishes of Study Area

Common Name	Scientific Name	Special Status
Spotted gar	*Lepisosteus oculatus*	
Longnose gar	*Lepisosteus osseus*	Commercial
Florida gar	*Lepisosteus platyrhincus*	
Bowfin	*Amia calva*	Nuisance
American eel	*Anguilla rostrata*	
Gizzard shad	*Dorosoma cepedianum*	Nuisance
Threadfin shad	*Dorosoma petenense*	
Redfin pickerel	*Esox americanus*	Sport
Chain pickerel	*Esox niger*	Sport
Golden shiner	*Notemigonus crysoleucas*	Forage
Ironcolor shiner	*Notropis chalybaeus*	Forage
Pugnose minnow	*Notropis emiliae*	Forage
Taillight shiner	*Notropis maculatus*	Forage
Coastal shiner	*Notropis petersoni*	Forage
Sailfin shiner	*Notropis hypselopterus*	Forage
Blackspot shiner	*Notropis atrocaudalis*	Forage
Bullhead minnow	*Pimephales vigilax*	Forage
Lake chubsucker	*Erimyzon sucetta*	
White catfish	*Ictalurus catus*	Commercially important
Yellow bullhead	*Ictalurus natalis*	
Brown bullhead	*Ictalurus nebulosus*	Commercially important
Channel catfish	*Ictalurus punctatus*	Commercially important
Tadpole madtom	*Noturus gyrinus*	
Pirate perch	*Aphredoderus sayanus*	Forage
Bluefin killifish	*Lucania goodei*	Forage
Pygmy killifish	*Leptolucania ommata*	Forage
Seminole killifish	*Fundulus seminolis*	Forage
Golden topminnow	*Fundulus chrysotus*	Forage
Lined topminnow	*Fundulus lineolatus*	Forage
Flagfish	*Jordanella floridae*	Forage
Sheepshead minnow	*Cyprinodon variegatus*	Forage
Goldspotted killifish	*Floridichthys carpio*	Forage
Rainwater killifish	*Lucania parva*	Forage
Banded killifish	*Fundulus diaphanus*	Forage
Starhead topminnow	*Fundulus notti*	Forage
Mosquitofish	*Gambusia affinis*	Forage
Least killifish	*Heterandria formosa*	Forage
Sailfin molly	*Poecilia latipinna*	Forage
Brook silverside	*Labidesthes sicculus*	Forage
Striped bass	*Morone saxatilis*	Sport
Sunshine bass	*Morone chrysops* x *saxatilis*	Sport
Bluespotted sunfish	*Enneacanthus gloriosus*	Forage
Warmouth	*Lepomis gulosus*	Sport
Bluegill	*Lepomis macrochirus*	Sport
Dollar sunfish	*Lepomis marginatus*	Forage
Redear sunfish	*Lepomis microlophus*	Sport
Spotted sunfish	*Lepomis punctatus punctatus*	Sport
Largemouth bass	*Micropterus salmoides*	Sport
Black crappie	*Pomoxis nigromaculatus*	Sport
Everglades pygmy sunfish	*Elassoma evergladei*	Forage
Okefenokee pygmy sunfish	*Elassoma okefenokee*	Forage
Redbreast sunfish	*Lepomis auritus*	Sport
Longear sunfish	*Lepomis megalotis*	Sport
Swamp darter	*Etheostoma fusiforme*	Forage
Brown darter	*Etheostoma edwini*	Forage

*Exclusive of introduced tropical forms

Commercial — less than $1,000 dockside value within a county (Charlotte, Manatee, Hillsborough, Sarasota)

Commercially important — greater than $1,000 dockside value within a county (Charlotte, Manatee, Hillsborough, Sarasota)

Sport — sought after by sportfishermen

Forage - food fish for larger predators

Table 2.7. Occurrences and Relative Abundances of Fishes in Lentic Habitats within Seven Counties of Study Area

Lentic Fishes	Polk Co.	Hillsborough Co.	Hardee Co.	Manatee Co.	DeSoto Co.	Sarasota Co.	Charlotte Co.
Longnose gar	U	-	-	-	-	-	-
Florida gar	O	O	-	P	-	-	-
Bowfin	O	O	-	-	-	-	-
American eel	R	-	-	-	-	-	-
Gizzard shad	A	C	-	-	-	-	-
Threadfin shad	A	R	-	-	-	-	-
Redfin pickerel	-	R	-	-	-	-	-
Chain pickerel	U	R	-	-	-	-	-
Golden shiner	U	C	R	-	-	-	-
Ironcolor shiner	-	C	-	-	-	-	-
Taillight shiner	U	C	-	-	-	-	-
Coastal shiner	R	C	-	-	-	-	-
Sailfin shiner	-	C	-	-	-	-	-
Lake chubsucker	U	O	-	-	R	-	-
White catfish	U	U	-	-	-	-	-
Yellow bullhead	R	O	-	-	-	-	-
Brown bullhead	O	O	-	-	-	-	-
Channel catfish	C	P	P	-	-	-	-
Tadpole madtom	R	O	-	-	-	-	-
Walking catfish	-	P	-	-	-	-	-
Pirate perch	-	O	-	-	-	-	-
Needlefish sp.	R	-	-	-	-	-	-
Bluefin killifish	C	A	-	P	-	-	-
Seminole killifish	U	U	-	P	-	-	-
Golden topminnow	-	O	-	-	R	-	-
Flagfish	-	O	-	-	O	-	-
Mosquitofish	U	A	-	P	A	-	-
Least killifish	-	C	-	-	R	-	-
Sailfin molly	R	O	-	P	R	-	-
Florida brook silverside	O	C	-	-	-	-	-
Striped bass	U	U	-	-	-	-	-
Sunshine bass	U	U	-	-	-	-	-
Bluespotted sunfish	R	C	-	-	-	-	-
Warmouth	U	R	-	P	C	-	-
Bluegill sunfish	C	A	A	P	-	-	-
Dollar sunfish	R	O	-	-	R	-	-
Dollar spotted sunfish	R	U	-	-	-	-	-
Eastern redear sunfish	O	U	C	-	-	-	-
Largemouth bass	O	O	C	-	-	-	-
Florida largemouth bass	-	C	-	-	-	-	-
Black crappie	U	U	-	-	-	-	-
Everglades pygmy sunfish	-	O	-	-	-	-	-
Okefenokee pygmy sunfish	-	R	-	-	-	-	-
Redbreast sunfish	-	O	-	-	-	-	-
Longear sunfish	R	-	-	-	-	-	-
Swamp darter	U	C	-	-	-	-	-
Armored catfish	-	P	-	-	-	-	-
Blackchin tilapia	-	P	-	-	-	-	-
Black molly	-	P	-	-	-	-	-
Blue tilapia	A	A	-	-	-	-	-
Cichlasoma trimaculatum	-	-	-	A	-	-	-
Climbing perch	-	-	-	P	-	-	-
Congo tilapia	P	-	-	-	-	-	-
Dwarft gourami	-	P	-	-	-	-	-
Green swordtail	-	P	-	-	-	-	-
Guppy	-	P	-	-	-	-	-
Hoplias	-	P	-	-	-	-	-
Jack dempsey	-	P	-	-	-	-	-
Jewelfish	-	P	-	-	-	-	-
Mozambique tilapia	-	P	-	-	-	-	-
Red swordtail	-	P	-	-	-	-	-
Rio-Grande perch	P	P	-	-	-	-	-
Southern platyfish	-	P	-	-	-	-	-
Swordtail molly	-	P	-	-	-	-	-
Tilapia macrocephala	-	P	-	-	-	-	-
Tilapia nilotica	-	P	-	-	-	-	-
Twospot climbing perch	-	-	-	P	-	-	-
Variable platyfish	-	P	-	-	-	-	-

*Florida Game and Fresh Water Fish Commission (1968, 1975)
Florida Committee on Rare and Endangered Plants and Animals (1976)
Courtenay et al (1974)
Starling (1975)
Texas Instruments Incorporated (1977)

A = Abundant
C = Common
O = Occasional occurrences
U = Uncommon
R = Rare
P = Present, but with no indication of abundance

A typical nearshore fish community within larger lakes and impoundments generally comprises a number of smaller forage species (e.g., shiners, killies and livebearers, smaller sunfish, and catfish) that utilize these shallow, protected, often vegetated areas for feeding, spawning, and as a nursery. The shore zones and nearshore waters are also populated by young and adult predatory species (e.g., centrarchid basses, pickerels, catfish, bowfins, and gar), which utilize the areas for the same purposes. The more open and somewhat deeper waters of these lakes are generally inhabited by pelagic or water-column species (e.g., shads, percichthyid basses, and silversides) as well as by bottom-dwelling species (e.g., suckers and catfish).

Based on reported occurrence as well as catch data (primarily from Polk and Hillsborough counties) collected during TI's field reconnaissance, some of the more abundant or common fish species in the 7-county study area are the gizzard and threadfin shad, channel catfish, largemouth bass, blue tilapia, bluefin killifish, Florida gar, bluegill, and lake chubsucker (Table 2.7).

Populating many of the smaller ponds, ditches, canals, and sloughs dispersed throughout the study area are native and exotic fish species that have (1) emigrated or been transported as young from larger standing water bodies or mainstem rivers and streams during heavy rain and subsequent flooding or (2) been purposely or accidentally introduced or have escaped from fish hatcheries or farms within or outside the study area. Species capable of surviving the stringent environmental conditions common to these shallow and generally intermittent habitats have short life cycles and a high reproductive potential that result in rapid population expansion during periods of elevated water levels. The native fish community commonly occurring in these habitats generally comprises killifish, livebearers, shiners, and sunfish: within these groups are the mosquitofish (*Gambusia*, which often dominates the community), golden topminnow, flagfish, least killifish, sailfin molly, bluespotted and pygmy sunfish, and warmouth.

B. LOTIC COMMUNITIES

The lotic, or running water, communities are represented by the biotic assemblages of the rivers, streams, and tributaries of the 7-county study area. The communities generally are rich and diverse, and the major water courses as a whole are of considerable aesthetic and recreational importance to the study area, serve as sources of water supply, and support substantial sport and commercial fisheries.

Typical of others in the southeastern Coastal Plain, most streams in the study area exhibit a tea water color imparted by dissolved organic acids that are washed from adjacent standing water during abundant rainfall. Current speed varies among (and within) the streams: many are comparatively slow and moderately to heavily covered with emergent aquatic vegetation. Both the appearance and biotic composition of the slow streams are similar to those of lakes and ponds, with substantial development of planktonic communities and widely ranging macroinvertebrates common. The swifter streams contain little emergent and floating vegetation, have few resident zooplankters, and support populations of narrowly ranging and sessile macroinvertebrates that filter feed or graze.

This discussion of the biota of the lotic communities considers six major watersheds or basins: the Peace, Myakka, Manatee, Little Manatee, Alafia, and Hillsborough. The hydrological and physicochemical characteristics of the major streams in the study area are discussed in Chapter 1 of this volume.

1. Flora

a. Algae

Phytoplankton and periphyton are the prevalent algal communities in running water as they are in standing water. In lotic situations, however, the attached algae are by far the most ecologically significant. These algal communities may be seen as golden-brown coloration over the surface of rocks and rubble; brillant bluegreen mats over the silt in quiet, shallow areas; long, green benthic streamers; and brown or green scum on submerged objects such as limbs and logs. Such growths generally are associated with shallow sunlit depths and areas of relatively stable substrate. Algae suspended in the water column of lotic waters are typically not euplanktonic (true) phytoplankton but an assemblage of benthic forms that have been swept into the water column and planktonic forms that have developed in quieter adjacent waters and been washed into the main water course. Euplanktonic communities often develop, however, near the mouths of rivers or streams where water velocity decreases.

Table 2.8 lists the algae reported from the six major watersheds of the study area and indicates their relative abundances. Except for recent investigations of the lower Peace River (TI 1977) and the Alafia and Little Manatee (Dames and Moore 1975), comprehensive information is generally sparse; however, one would expect algae common to the Peace, Alafia, and Little Manatee rivers to occur also in the Myakka, Manatee, and Hillsborough drainages.

In the Alafia River, diatoms apparently are the most abundant phytoplankton with *Nitzchia, Navicula, Eunotia* and unidentified centric diatoms being the prevalent taxa (Dames and Moore 1975). *Pinnularia* dominated in the fall but was absent the following winter and spring. *Peridinium*, a dinoflagellate, was a common but less abundant form in each season; however, it was a prevalent form, along with *Skeletonema costatum*, in the brackish waters at the river mouth, reaching a density exceeding 3,000,000 cells per liter in the fall. The green alga *Mougeotia* was relatively abundant upriver during fall but was absent in winter and spring. Bluegreen algae and euglenoids, although present in all sampling periods, were much less abundant than either the diatoms, dinoflagellates, or green algae. The macroscopic green alga *Chara* was observed during each season near the junction of State Highway 39 and the Alafia River (Aldermans Ford).

Phytoplankton taxa and abundances in the Little Manatee River are similar to those in the Alafia River (Dames and Moore 1975). Diatoms (principally *Nitzchia, Navicula, Cocconeis,* and unidentified centric forms) were the most prevalent group, followed by the dinoflagellate *Peridinium*. The filamentous green alga *Oedogonium* was reported in benthic mat formations in the middle reaches of the river, and another filamentous alga, the bluegreen *Oscillatoria*, was abundant during spring farther upriver.

Table 2.8. Occurrences and Relative Abundances of Algae in Six Major River Basins within Study Area*

Lotic Algae	Peace	Myakka	Manatee	Little Manatee	Alafia	Hillsborough
				River Basin		
Cyanophyta						
Oscillatoria	A	NO DATA	NO DATA	R	-	NO DATA
Agmenellum	C			R	-	
Lyngbya	C			-	-	
Microcystis	C			-	-	
Anabaena	O			-	-	
Aphanocapsa	O			-	-	
Phormidium	U			-	-	
Schizothrix	U			-	-	
Spirulina	U			-	-	
Calothrix	U			-	-	
Pleurocapsaceae (unspecified)	U			-	-	
Chroococcus	O			R	-	
Aphanothece	U			-	-	
Chlorophyta						
Scenedesmus	A			O	P	
Rhizoclonium	A			-	P	
Chlamydomonas	A			-	-	
Ankistrodesmus	C			U	O	
Spermatozoopsis	C			-	-	
Oocystis	O			R	U	
Closterium	O			-	U	
Crucigenia	O			R	U	
Pediastrum	O			-	-	
Cladophora	O			-	-	
Cosmarium	O			-	-	
Gleocystis	O			-	-	
Tetraedron	O			-	-	
Spirogyra	O			-	-	
Oedogonium	U			-	P	
Mougeotia	R			R	O	
Actinastrum	U			-	U	
Closteriopsis	-			U	U	
Sphaerocystis	U			-	-	
Eudorina	U			-	-	
Kirschneriella	U			-	-	
Micractinium	U			-	-	
Coelastrum	U			-	-	
Ulothrix	U			-	-	
Chaetophorales (unspecified)	U			-	-	
Treubaria	-			-	U	
Tetrastrum	R			R	-	
Tetraspora	R			-	-	
Characium	R			-	-	
Hydrodictyon	R			-	-	
Hormidium	R			-	-	
Protoderma	R			-	-	
Entocladia	R			-	-	
Gonium	R			-	-	
Quadrigula	R			-	-	
Dictyosphaerium	R			-	-	
Shroederia	U			-	-	
Xanthidium	P			-	-	

*Lanquist (1953)
Dames and Moore (1975)
Texas Instruments Incorporated (1977)

A = Abundant
C = Common
O = Occasional occurrences
U = Uncommon
R = Rare
P = Present, but with no indication of abundance

Table 2.8 (Contd)

Lotic Algae	River Basin					
	Peace	Myakka	Manatee	Little Manatee	Alafia	Hillsborough
Bacillariophyta						
Nitzchia	C	NO DATA	NO DATA	A	A	NO DATA
Navicula	C			A	A	
Fragillaria	A			-	P	
Opephora	A			-	-	
Melosira	C			O	C	
Cococneis	C			C	O	
Pinnularia	O			R	C	
Cyclotella	C			-	-	
Gomphonema	O			O	O	
Achnanthes	C			-	-	
Eunotia	U			O	C	
Cymbella	O			U	O	
Bacillaria	O			O	-	
Synedra	U			U	O	
Gyrosigma	U			U	U	
Amphiprora	P			-	O	
Amphora	O			-	-	
Chaetoceros	-			-	O	
Frustulia	U			-	R	
Surirella	U			-	U	
Diploneis	O			R	-	
Diatoma	U			-	-	
Dimerogramma	U			-	-	
Thalassiosira	O			-	-	
Neidium	U			-	-	
Skeletonema	U			-	-	
Microsiphona	U			-	-	
Aphora	U			-	-	
Terpsinoe	P			-	P	
Meridion	R			-	P	
Campyloneis	R			-	-	
Pleurosigma	R			-	-	
Denticula	R			-	-	
Cymatopleura	R			-	-	
Caloneis	R			-	-	
Capartogramma	R			-	-	
Coscinodisus	R			-	-	
Stephanodisus	R			-	-	
Cymatosira	R			-	-	
Desmogonium	R			-	-	
Mastogloia	R			-	-	
Epithemia	R			-	-	
Stauroneis	P			-	-	
Rhoicosphenia	P			-	-	
Chrysophyta						
Mallomonas	U			NO DATA	NO DATA	
Dinobryon	U					
Rhizochrysidales (unspecified)	U					
Isochrysidales (unspecified)	R					
Monosigales (unspecified)	R					
Desmarella	R					
Monosiga	R					
Euglenophyta						
Euglena	O			U	O	
Phaeus	U			R	U	
Trachelomonas	U			-	U	
Lepocinclis	R			-	U	
Pyrrhophyta						
Peridinium	C			C	C	
Gonyaulax	C			-	-	
Ceratium	O			-	-	
Gymnodinium	U			-	-	
Xanthophyta						
Vaucheria	O			-	-	
Tribonema	U			-	-	
Bumillaria	R			-	-	
Cryptophyta						
Rhodomonas	A			-	-	
Cryptomonas	C			-	-	
Chroomonas	C			-	-	
Monomastix	R			-	-	
Charophyta						
Chara	O			-	-	

Phytoplankton chlorophyll *a* content, which is a measure of production, also was similar in both rivers, ranging from near zero to 0.033 milligrams per liter in the fresh water of the Alafia and from near zero to 0.04 milligrams per liter in the fresh water of the Little Manatee (Dames and Moore 1975). The rivers apparently exhibit little difference in phytoplankton standing crop, as measured by densities or chlorophyll values, although the Alafia's inorganic nutrient content is several times that of the Little Manatee.

The composition and abundance of phytoplankton of the Peace River from a point near Gardner to the mouth of the river shows a salient relationship with river flow (TI 1977). Green algae and diatoms numerically dominate during low flow (January-May), whereas bluegreens numerically dominate during increased flow (June-October). On a biovolume basis, diatoms are prevalent during low flow; green algae are principal contributors to biomass during increased flow. When considering both numbers and biomass, it appears that green algae generally dominate the phytoplankton of the lower Peace River most, if not all of the year.

The greens most commonly found in the lower Peace River are *Scenedesmus*, *Chlamydomonas*, and *Oedogonium* (TI 1977). Diatoms prevalent during low flow are *Melosira*, *Fragilaria*, and *Opephora*. Bluegreens that represent predominate percentages of phytoplankton numbers during high flow but contribute relatively little to biovolume are the filamentous *Oscillatoria* and *Lyngbya* and the coccoid *Microcystis*.

Total phytoplankton densities measured for the Peace River averaged from about 328,000 cells per liter in February to about 137,770,000 cells per liter in October (TI 1977). Lowest abundances occurred from January-March; as abundance increased, two peaks occurred — a minor one in June and a major one in October. Phytoplankton biovolume followed a similar trend.

The known periphyton, or attached algae, of the lower Peace River consists of 75 diatom, 35 green, 11 bluegreen, 1 dinoflagellate and 2 cryptomonad taxa (TI 1977). Diatoms dominated in January and October, with *Fragilaria* most prevalent. Greens were dominant in April with *Scenedesmus* most abundant. The most common forms in July were the bluegreens, with *Lyngbya* predominating.

Taxa represented all four seasons are *Oscillatoria, Oedogonium, Melosira, Nitzchia, Fragilaria, Opephora, Achnanthes, Cocconeis,* and *Navicula.* The greatest diversity of periphyton taxa was noted in October.

The reported absence of nuisance algal growths in streams of the study area was corroborated during TI's March 1977 field reconnaissance of the area.

b. Vascular Plants

Aquatic vascular flora in moderate quantities is an important component of the lotic community, contributing habitat for animals, organic matter to the lotic food web, and stability to the stream banks; an overabundance however, clogs waterways, depletes oxygen levels during die-offs, and causes undesirable alterations in communities. (The nuisance growth of certain plants in streams of the study area is discussed in Section 3). The presence of a given aquatic vascular plant along a river or stream is generally a function of substrate type and water velocity and transparency. Seldom are beds or growths of a particular plant continuous along a stream bank; rather, they occur more or less irregularly where conditions are most suitable for survival. Distribution and extent are seasonal functions controlled largely by temperature, amount of daylight, and streamflow.

Table 2.9 lists the vascular plants found in lotic fresh water in the study area and indicates their relative abundances. As the references indicate, there have been substantial studies of aquatic vascular plants in the Peace, Little Manatee, Alafia, and Hillsborough river basins but no published reports on aquatic vasculars of the Myakka and Manatee river basins.

The most abundant aquatic vasculars recently found in the Peace River were pondweed, water-pennywort, widgeon grass, smartweed, water hyacinth, aligator weed, shoal grass, and bulrush (TI 1977). Previously, eelgrass, pickerel-weed, false loosestrife, water primrose, and panic grass were reported to be locally abundant in the river (Lanquist 1953). Greatest abundances generally occur in late spring, following growth during the months of low flow (TI 1977). Each year, the plant communities are essentially destroyed by high flows during the wet season (July-September).

Table 2.9. Occurrences and Relative Abundances of Aquatic Vascular Plants in Six Major Basins of Study Area

	River Basin					
Taxon	Peace	Myakka	Manatee	Little Manatee	Alafia	Hillsborough
Water hyacinth *(Eichhornia crassipes)*	C	No Data Available	No Data Available	A	C	A
Rush *(Juncus* spp.*)*	C			A	A	-
Panic grass *(Panicum* spp.*)*	C			A	-	C
Smartweed *(Polygonum* spp.*)*	C			P	A	C
Pickerel-weed *(Pontedaria lanceolata)*	O			A	-	A
Yellow pond lily *(Nuphar luteum)*	O			A	-	A
Water pennywort *(Hydrocotyle umbellata)*	C			P	O	C
Duckweed *(Lemna* spp.*)*	C			R	C	C
Cattail *(Typha* sp.*)*	-			-	A	C
Water primrose *(Ludwigia repens)*	A			-	-	C
False loosestrife *(Ludwigia peruviana)*	A			-	-	C
Water purslane *(Ludwigia* sp.*)*	-			-	A	-
Eelgrass *(Vallisneria neotropicalis)*	C			-	-	A
Bushy pondweed *(Najas* spp.*)*	C			-	A	-
Waterweed *(Elodea* spp.*)*	-			C	A	-
Spike rush *(Eleocharis* spp.*)*	-			C	A	-
Hydrilla *(Hydrilla verticillata)*	-			O	-	A
Water fern *(Salvinia rotundifolia)*	O			-	-	A
Aquatic moss *(Leptodictyum* sp.*)*	P			-	A	-
Water marigold *(Megalcdontia beqkii)*	-			P	A	-
Pondweed *(Potamogeton* spp.*)*	C			C	P	-
Water grass *(Hydrochlora carolinensis)*	U			-	-	A
Coontail *(Ceratophyllum* spp.*)*	-			-	C	C
Water fern *(Azolla caroliniana)*	-			C	-	C
Ergeria *(Ergeria densa)*	-			-	-	A
Paspalum *(Paspalum fluitans)*	-			-	-	A
Water plantain *(Alisma* sp.*)*	-			A	-	-
Water milfoil *(Myriophyllum heterophyllum)*	-			-	A	-
Arrowhead *(Sagittaria* spp.*)*	O			-	P	C
Water lettuce *(Pista stratiotes)*	O			-	-	C
Alligator weed *(Alternanthera philoxeroides)*	C			-	O	-
Widgeon grass *(Ruppia maritima)*	C			-	-	-
Shoal grass *(Halodule* spp.*)*	C			-	-	-
Bulrush *(Scirpus conferucides)*	C			-	-	-
Waterwort *(Elatine* sp.*)*	-			-	C	-
Dock *(Rumex* spp.*)*	C			-	-	-
Aquatic liverwort *(Riccia fluitans)*	-			C	-	-
Fanwort *(Cabomba caroliniana)*	-			O	-	U
St. John's-wort *(Hypericum boreale)*	-			U	P	-
American frog's-bit *(Lumnobium spongia)*	O			-	-	-
Cape weed *(Lippia nodiflora)*	O			-	-	-
Water hyssop *(Bacopa monnieri)*	O			-	-	-
Wild orchid *(Habenaria* sp.*)*	O			-	-	-
Floating heart *(Nymphoides* sp.*)*	O			-	-	-
Micranthemum *(Micranthemum umbrosum)*	O			-	-	U
Bog moss *(Mayaca* sp.*)*	U			-	-	-
Colocasia *(Colocasia esculentum)*	-			-	-	U
Thalia *(Thalia geniculata)*	U			-	-	-
Bur reed *(Sparganium* sp.*)*	-			-	P	-
Dwarf-burhead *(Echinodorus tenellus)*	-			P	-	-
Hedge hyssop *(Gratiola viscidula)*	-			-	P	-
Centella *(Centella erecta)*	-			P	-	-

*Lanquist (1953)
Texas Instruments Incorporated (1977)
W.R. Grace (1975)
Dames and Moore (1975)
Cowell et al (1974)
Beck and Cowell (1976)

A = Abundant
C = Common
O = Occasional occurrences
U = Uncommon
R = Rare
P = Present, but with no indication of abundance

In the Little Manatee River, water hyacinth, pickerel weed, water plaintain, yellow pond lilly, pondweed, and *Elodea* are the common aquatic macrophytes (Dames and Moore 1975); the main channel in the river's lower reaches is often completelv covered with water hyacinth.

In the Alafia River, bushy pondweed, *Elodea*, and water milfoil are the abundant submergent macrophytes (Dames and Moore 1975). A bryophyte, *Fissidens*, is abundant over areas of clay substrate in the shallow riffles; shoreline areas are generally vegetated by smartweed, spike rush, and water purslane, with cattail abundant along the shoreline in uppermost reaches. There are frequent patches of water hyacinth, which is concentrated along the bank by physical obstructions at the water surface; in quiet backwater areas, duckweed is locally abundant.

The most abundant aquatic macrophytes of the Hillsborough River are spatterdock, water hyacinth, *Hydrilla*, eelgrass, *Ergeria*, pickerel-weed, *Paspalum*, waterfern (*Salvinia*), and duckweed (Cowell et al 1974). Nuisance growths of water hyacinth, spatterdock, *Hydrilla*, and *Ergeria* are common throughout the drainage. Cowell et al noted three major plant habitats within the Hillsborough River drainage: shallow runs in heavy swamp forests; areas of moderate to swift current in more open (less canopied) areas of swamp forests; and large open areas of comparatively deep water (to 5 meters, or 15 feet) and little or no current. Few plants occur in the shallow runs of the Hillsborough because of extensive shading, but water hyacinth, spatterdock, arrowhead, and *Colacasia* appear in patches where sunlight penetrates the canopy. The swift current habitat contains large populations of eelgrass and ergeria; along the shores of this habitat type are extensive growths of false loosestrife, smartweed, arrowhead, and *Paspalum*. The open habitat contains a wide varietv of species, but water hyacinth, spatterdock, *Hydrilla*, *Ergeria*, and pickerel-weed are especiallv abundant. Large populations of floating plants such as duckweed and water fern (*Azolla* and *Salvinia*) also occur in this habitat. There are no marked seasonal differences in plant species.

2. Fauna

a. Zooplankton

Comprehensive information on zooplankton in the study area's streams is limited to two studies of the Peace River basin — one in the upper portion (CFMI 1976) and one in the lower portion (TI 1977). A list of zooplankters reported in the two investigations and indications of relative abundances are in Table 2.10.

Table 2.10. Occurrences and Relative Abundances of Zooplankton Reported from Lotic Habitats in Peace River Drainage

Taxa	Relative Abundance*
Protozoa	
Rhizopodea (unspecified)	U
Cnidaria	
Hydrozoa (unspecified)	C
Rotifera	
Keratella	A
Lecane	A
Monostyla	A
Synchaeta	A
Asplanchna	P
Beauchampiella	P
Brachionus	P
Cephalodella	P
Euchalanis	P
Filinia	P
Lepadella	P
Mytilina	P
Notholca	P
Platyias	P
Ploesoma	P
Testudinella	P
Trichocerca	P
Trichotria	P
Anostraca (unspecified)	R
Cladocera	
Bosminidae (unspecified)	C
Leptodoridae (unspecified)	R
Chydoridae (unspecified)	C
Alona	C
Chydorus	C
Camptocercus	O
Leydigia	O
Dunhevedia	O
Euryalona	O
Kurzia	U
Pleuroxus	R
Daphnidae	
Simocephalus	C
Ceriodaphnia	C
Daphnia	O
Scapholeberis	U
Moinadaphnia	U
Moina	U
Macrothricidae	
Ilyocryptus	C
Macrothrix	C
Lathonura	O
Grimaldia	U
Polyphemidae	
Podon	O
Evadne	R
Sididae	
Diaphanosoma	O
Latonopsis	O
Sida	U
Copepoda	
Calinoida	
Diaptomus	O
Osphranticum	O
Acartia	U
Labidocera	R
Temora	R
Eurytomora	R
Cyclopoida	
Eucyclops	A
Cyclops	C
Macrocyclops	C
Tropocyclops	C
Mesocyclops	O
Paracyclops	O
Oithona	U
Ergasilus	U
Halicyclops	R
Harpacticoida (unspecified)	C
Caligoida (unspecified)	R

A = Abundant
C = Common
O = Occasional occurrences
U = Uncommon
R = Rare
P = Present, but with no indication of abundance

Of the approximately 180 zooplankton taxa identified in the lower Peace River, the most common are midge larvae, cyclopoid copepods in the genera *Eucyclops* and *Macrocyclops*, and mayfly larvae in the families Baetidae and Caenidae (TI 1977). During low flow (January-May) the community is dominated by meroplankton, principally midge larvae (mostly *Tanytarsus*) and mayfly larvae. During increased flow (June-October), several major groups of organisms either not or only occasionally observed during the dry season are present. Several species of the cladoceran genus *Daphnia* (waterfleas) are observed most often during July and August, the period of highest river discharge. Occurrences of these and certain other plankters in the lower Peace River appear directly related to surface runoff from ponds and lakes. The admixture of zooplankters indigenous to the Peace River and those brought in with surface runoff from adjacent lentic communities increases diversity considerably during the wet season (60 to 100 taxa) as opposed to the dry season (33 to 57 taxa).

Zooplankton biomass also exhibits a salient dry/wet seasonal pattern, with higher dry weight biomass during low flow (TI 1977). The meroplankton component, consisting of larger individuals, dominates the biomass throughout most if not all of the year. Holoplankton biomass was highest in June and July, corresponding to the high relative abundances of copepods and cladocerans. Total zooplankton biomass values ranged from a high of approximately 9 milligrams per cubic meter in January (primarily midge larvae) to a low of approximately 0.3 milligrams per cubic meter in June.

Periods of low flow in the Peace River exhibit substantial diel (24-hour periodicity) variations in both numbers and biomass of zooplankton (TI 1977). These variations can be attributed to diel activity patterns of certain meroplankters (midge larvae and mayfly larvae) that numerically dominated the zooplankton community during low flow.

The basic compositional and seasonal characteristics of the zooplankton of all major streams in the study area should be similar to those of the Peace River, although species may vary somewhat in local situations.

b. Macroinvertebrates

As in lentic communities, the macroinvertebrates of lotic communities play a significant role in the degradation and cycling of detrital materials that otherwise would accumulate as bottom sediments, resulting in a consequent loss of energy to the ecosystem. Because of their relatively greater ecological role in the lotic ecosystem and their value as water-quality indicators, the macroinvertebrates of streams of the study area have received considerably more attention than the zooplankton. Table 2.11 lists macroinvertebrates recorded in lotic habitats within the study area and indicates their relative abundances.

Approximately 143 macroinvertebrate taxa, 122 of which were insects (principally midge larvae, dragonfly and damselfly larave, and adult and larval aquatic beetles), are recorded in the lower Hillsborough flood detention area (Cowell et al 1974). The Asiatic clam (*Corbicula*), an introduced species, is extremely abundant. Similar numbers of taxa (usually 49 to 52) were found in each of four areas, and many of the taxa appear common to all areas. Generally, mayfly larvae, mollusks (snails and bivalves), and dragonfly (Gomphidae) larvae appear more abundant in upstream swamp-forest areas while damselfly larvae and midge larvae appear more abundant in downstream areas.

Benthic invertebrates appear dense all along the lower Hillsborough River; densities ranged from approximately 3,000 to more than 25,000 organisms per square meter (Cowell et al 1974). Oligochaete worms comprised about 38 percent of total numbers, mollusks about 33 percent, and midge larvae about 26 percent. Midges were most numerous in association with aquatic plants. Mollusks, particularly *Corbicula*, were most abundant in the currents of shallow, clear areas. Large abundances of the freshwater caridean shrimp *Palaemonetes paludosus* also have been reported in association with vegetation in the Hillsborough River (Beck and Cowell 1976).

Freshwater macroinvertebrates commonly found in the middle and upper reaches of the Alafia River are oligochaetes and mayfly, caddisfly, midge, and ceratopogonid (biting midge) larvae (Dames and Moore 1975). Diversity appears highest in a portion of the south prong of the Alafia; it appears only somewhat lower at Alderman's Ford where densities, which ranged from 1,170 to more than

22,300 per square meter were consistently highest. The latter is characterized by a variety of habitat — a wide, shallow (about 0.5-meter, or 1.5-foot) glide with fast currents running over luxuriant growths of moss (*Fissidens*) on a hard clay substrate at midstream and bordered by quiet, heavily vegetated shore areas. The area apparently is stable: during TI's field reconnaissance in March 1977, it appeared virtually the same as described by Dames and Moore (1975) in 1973-74, the major exception being that both *Corbicula* and *Palaemonetes* appeared more abundant in 1977 than previously reported.

That macroinvertebrate composition normally varies somewhat from place to place in a stream (Minshall 1969) is readily apparent in the Little Manatee River where: occurring most commonly in the lower freshwater reaches are bivalves, aquatic beetles, midges, and oligochaetes; in the middle portion, midges, biting midges, oligochaetes, and mayflies; and in the upper portion, midges, biting midges, oligochaetes, and isopods (Dames and Moore 1975). Greatest densities and diversities generally occur in the middle portion of the river.

Approximately 124 macroinvertebrate taxa were identified in the Peace River during 1976 (TI 1977). Numbers of taxa recorded ranged from 32 (May) to 61 (March). Most common were tubificid worms, the Asiatic clam (*Corbicula*), mayfly larvae (*Baetis* and *Caenis*), dragonfly larvae (principally *Gomphus*), midges (*Tanytarsus* and *Cryptochironomus*), and biting midges. Maximum numerical densities ranged from approximately 11,400 organisms per square meter in May to about 2,500 in September. The sharp decrease in densities reflects the scouring phenomonon associated with increased stream flow (Hynes 1970); Lanquist (1953) noted a similar decline in an earlier study of the Peace River.

The most stable constituent of the benthic fauna in the lower Peace River is the tubificids (sludge worms) (TI 1977); the percentage of these organisms relative to the total community increased throughout the dry season, decreased slightly in July, and then increased sharply to complete dominance in September. The primary codominant during the dry season was the midge *Tanytarsus* sp., which decreased in relative abundance as the tubificids increased. The primary codominant with the oligochaetes during the wet season was *Corbicula*, which comprised the major portion of the community in July.

Table 2.11. Occurrences and Relative Abundances* of Macroinvertebrates in Six Major Basins within Study Area

Lotic Macroinvertebrates	Peace	Myakka	Manatee	Little Manatee	Alafia	Hillsborough
Porifera						
Spongilla	0	No Data Available	No Data Available	-	-	-
Cnidaria						
Hydrozoa	0			-	-	-
Platyhelminthes						
Turbellaria	0			-	-	-
Nemertinea						
Prostoma	0			-	-	-
Nematoda (unspecified)	0			-	-	-
Annelida						
Polychaeta (unspecified)	U			R	R	-
Oligochaeta (unspecified)	A			A	A	A
Naididae	C			-	-	-
Tubificidae	A			-	-	-
Lumbriculidae	P			-	-	-
Hirudinea (unspecified)	0			0	0	C
Helobdella	0			-	-	C
Mollusca						
Gastropoda						
Physa	C			0	0	C
Goniobasis	-			-	C	C
Ferrissia	C			-	-	C
Pleurocerea	-			-	-	A
Seliaona	0			0	R	C
Gyraulus	0			-	-	C
Pomacea	U			-	-	C
Gundlachia	R			-	-	C
Viviparus	U			-	0	0
Lymnaea	0			-	-	-
Crepidula	U			-	-	-
Menetes	U			-	-	-
Promenetes	P			-	-	-
Rissoa	U			-	-	-
Corambella	U			-	-	-
Bivalvia						
Corbicula	A			A	C	A
Sphaerium	0			C	0	A
Elliptio	0			-	-	0
Anodonta	U			-	-	0
Musculium	-			-	-	0
Mulinia	0			-	-	-
Micromya	0			-	-	-
Pisidium	0			-	-	-
Byssanodonta	0			-	-	-
Alasmidonta	-			-	0	-
Carunculina	U			-	-	-
Uniomerus	P			-	-	P
Villosa	P			-	-	-
Eupera	P			-	-	P
Arthropoda						
Cladocera (unspecified)	0			-	-	-
Copepoda (unspecified)	U			-	-	-
Ostracoda (unspecified)	0			-	-	-
Cirripedia (unspecified)	U			-	-	-
Isopoda (unspecified)	0			C	U	-
Chiridota	U			-	-	-
Aegothea	U			-	-	-
Exosphaeroma	U			-	-	-
Asellus	U			-	-	-
Amphipoda (unspecified)	A			U	0	-
Hyalleia	C			-	-	A
Crangonyx	0			-	-	U
Gammarus	0			-	-	-
Melita	U			-	-	-
Pentoporeia	U			-	-	-
Erichthonius	U			-	-	-
Decapoda (unspecified)	C			P	U	A
Palaemonetes	C			P	A	A
Procam barinae	C			P	C	-
Callinectes	0			-	-	-
Brachyura	U			-	-	-
Anomura	U			-	-	-
Acari						
Prostigmata (Hydracarina)	0			-	-	-
Ephemeroptera						
Caenis	C			C	U	C
Stenonema	C			0	-	C
Pseudocloeon	U			P	A	-
Neocloeon	-			P	A	-
Baetis	C			-	-	C
Tricorythodes	C			-	-	C
Baetidae (unspecified)	C			C	C	C
Callibaetis	0			-	0	C
Brachycercus	C			0	0	-
Hexagenia	0			-	-	-
Centroptilum	0			-	-	-
Choroterpes	R			-	-	-
Ephemerella	R			-	-	-
Habrophlebia	R			-	-	-
Odonata (unspecified)				C	0	-
Anisoptera						

*Lanquist (1953), Johnson (1972), Cowell et al (1974), CF Mining Industries (1976), Game and More (1975)

A = Abundant
C = Common
O = Occasional occurrences
U = Uncommon
R = Rare
P = Present, but with no indication of abundance

Table 2.11 (Contd)

Lotic Macroinvertebrates	Peace	Myakka	Manatee	Little Manatee	Alafia	Hillsborough
Macromia	O	No Data Available	No Data Available	-	U	C
Gomphus	C			-	-	O
Epidorauls	-			-	-	C
Dromogomphus	O			-	-	O
Libellula	O			-	-	O
Aphylla	O			-	-	O
Nasiaeschna	O			-	-	U
Pachydiplax	O			-	-	U
Erythemis	U			-	-	O
Coryphaeschna	-			-	-	U
Anax	-			-	-	U
Epicordulia	U			-	-	-
Tramea	-			-	-	U
Miathyria	-			-	-	U
Perithemis	U			-	-	-
Boyeria	U			-	-	-
Dythemis	R			-	-	-
Progomphus	R			-	-	-
Hagenius	R			-	-	-
Zygoptera						
Enallagma	O			-	-	C
Argia	C			-	-	O
Hetaerina	O			-	-	O
Ischnura	O			-	-	O
Anomalagrion	-			-	-	O
Lestes	R			-	-	U
Hemiptera						
Ranatra	O			-	-	C
Belostoma	C			-	-	O
Gerris	-			-	-	C
Mesovelia	-			-	-	C
Metrobates	-			-	-	O
Trepobates	-			-	-	O
Hydrometra	-			-	-	O
Rhagovelia	-			-	-	O
Sigara	-			-	-	O
Abedus	R			-	-	U
Notonecta	P			-	-	U
Macrovelia	-			-	-	U
Trichocorixa	-			-	-	U
Velia	-			-	-	U
Plea	U			-	-	-
Pelocoris	U			-	-	-
Buenoa	-			-	-	U
Lethocerus	R			-	-	-
Benacus	R			-	-	-
Rheumatobates	R			-	-	-
Coleoptera						
Dubiraphia	C			C	A	C
Stenelmis	C			O	A	C
Dineutus	O			-	-	C
Gyrinus	O			-	-	C
Peltodytes	O			-	R	U
Tropisternus	U			-	-	O
Berosus	O			-	-	U
Cubister	R			-	-	O
Enochrus	R			-	-	O
Haliplus	U			-	-	U
Laccophilus	U			O	O	U
Bidessus	-			-	-	O
Coptotomus	-			-	-	O
Hydrophilus	O			-	-	-
Hydrocanthus	-			-	-	O
Notomicrus	-			-	-	O
Cyphon	-			-	-	O
Copelatus	R			-	-	U
Simsonia	O			-	-	-
Noteridae (unspecified)	U			-	-	-
Dytiscidae (unspecified)	-			U	-	-
Agabus	-			-	-	U
Matus	-			-	-	U
Donacia	-			-	-	U
Ectopria	-			-	-	U
Microcylloepus	U			-	-	-
Hydaticus	R			-	-	-
Hydrochara	R			-	-	-
Pelonomus	R			-	-	-
Neuroptera (unspecified)	O			-	O	O
Chauliodes	R			-	-	U
Corydalus	O			-	-	-
Sialis	-			-	-	O
Trichoptera (unspecified)	C			O	A	C
Oecetis	C			-	-	C
Cheumatopsyche	C			-	-	C
Chimarra	C			-	-	-
Oxyethira	U			-	-	O
Psychomyiidae (unspecified)	O			-	P	U

Table 2.11 (Contd)

Lotic Macroinvertebrates	Peace	Myakka	Manatee	Little Manatee	Alafia	Hillsborough
Hydropsyche	O	No Data Available	No Data Available	-	-	-
Polycentropus	U			-	-	U
Neotrichia	O			-	-	-
Cyrnellus	O			-	-	-
Leptocella	O			-	-	-
Neureclipsis	U			-	-	-
Mayatrichia	U			-	-	-
Athripsodes	U			-	-	-
Triaenodes	R			-	-	-
Orthotrichia	R			-	-	-
Lepidoptera						
Parargyractis	O			-	-	-
Elophila	R			-	-	-
Diptera						
Ceratopogonidae (unspecified)	C			C	A	C
Polypedilum	A			C	C	C
Tanytarsus	A			A	O	U
Cricotopus	C			C	C	U
Ablabesmyia	C			-	C	C
Corynoneura	O			A	O	-
Harnischia	U			C	O	C
Procladius	P			C	U	U
Chironomus	O			O	C	U
Cryptochironomus	C			-	-	C
Eukiefferiella	P			U	C	-
Dicrotendipes	C			-	-	U
Pentaneura	O			O	O	U
Glyptotendipes	O			O	O	U
Clinotanypus	O			-	-	C
Rheotanytarsus	C			-	-	U
Paracladopelma	R			O	O	-
Stenochironomus	O			O	R	U
Micropsectra	O			-	R	U
Paralauterborniella	P			U	U	U
Pseudochironomus	O			O	-	-
Tribelos	U			O	-	-
Microtendipes	O			U	-	-
Psectrocladius	U			R	R	-
Thienemanniella	U			-	-	U
Labrundinia	R			-	-	U
Trichocladius	P			-	R	-
Cladotanytarsus	O			-	-	-
Chironomini (unspecified)	O			-	-	-
Prodiamesa	O			-	-	-
Stictochironomus	O			-	-	-
Goeldichironomus	U			-	-	-
Orthocladius	P			U	-	-
Paratendipes	-			U	-	-
Einfeldia	-			-	-	U
Constempellina	-			-	-	U
Coleotanypus	U			-	-	-
Parachironomus	U			-	-	-
Diamesa	-			-	-	U
Smittia	-			-	-	U
Nannocladius	R			-	-	-
Pedionomus	R			-	-	-
Pentapedilum	R			-	-	-
Cryptotendipes	R			-	-	-
Tanypus	R			-	-	-
Demicryptochironomus	P			-	-	-
Cryptocladopelma	P			-	-	-
Simuliidae (unspecified)	O			U	C	O
Simulium	O			-	-	-
Chaoborus	U			-	-	U
Anopheles	R			-	-	U
Uranotaenia	-			-	-	U
Tipulidae (unspecified)	O			-	-	-
Tipula	U			-	-	-
Ephydra	-			-	-	U
Dictya	-			-	-	U
Tubifera	R			-	-	-
Tabanidae (unspecified)	R			-	-	-
Tabanus	R			-	-	-
Atherix	R			-	-	-

Biomass within the benthic community was consistently dominated by *Corbicula*. It is interesting to note that *Corbicula*, although presently a predominant member of the benthic macroinvertebrate fauna of the Peace River, was not reported in earlier collections by Lanquist (1953); this suggests a relatively recent invasion of the Peace River by this exotic form.

Except for the possible loss of some bivalve species (other than *Corbicula*), there is no evidence of permanent damage to the Peace River benthic community by the massive phosphate slime spills of previous years.

Apparently no published information on macroinvertebrates of the Myakka or Manatee rivers exists, although there has been some limited monitoring by the Florida Department of Environmental Regulation. Biological monitoring data for these two streams is being provided by the DER and is expected to be received within the next several weeks. Upon receipt, the data will be reviewed and the information reported in an addendum that will also incorporate TI's findings during an August 1977 field reconnaissance of the study area.

c. Fishes

The study area's rivers and streams support a fish community comprising at least 72 native and exotic species. The majority of the native freshwater fishes represent a relatively small number of families including shiners (Cyprinidae), catfishes (Ictaluridae), killifishes (Cyprinodontidae), and sunfishes (Centrarchidae); many of the species within these families exhibit a generally wide natural distribution within the river drainages of the study area. A number of typically euryhaline (tolerant to broad changes in salinity) forms that include species of tarpons (Elopidae), mullets (Mugilidae), needlefishes (Belonidae), snooks (Centropomidae), and killifishes (Cyprinodontidae) ascend coastal streams, in some instances far beyond the limits of the salt wedge or tidal influence; in the Hillsborough River, however, this upstream movement essentially terminates at the Tampa waterworks dam located 10 miles upstream from the mouth of the river. A relatively small number of fish species occurring above the dam have some limited salinity tolerance, but the community comprises mostly freshwater species. Of the number of exotic fish species found, many appear to be well-established. Generally, these exotics compete either directly or indirectly with native species for some aspect of food or habitat needs. For example, the accidentally introduced blue tilapia (*Tilapia aurea*) has successfully adapted to the Peace River system and, despite major fish kills and predation, competes successfully with sunfishes for breeding and nesting space and with catfish for the limited aquatic vegetation available in the lower river.

Occurrences and relative abundances of fish species in six major drainage basins of the study area appear in Table 2.12. (Scientific names of the fishes appear in Table 2.6.)

The spatial and seasonal occurrences, distributions, and abundances are affected by a number of abiotic factors including rainfall, runoff and subsequent stream or river flow, water temperature, dissolved oxygen, and in the case of coastal streams, the extent of salinity intrusion from nearby estuarine/marine waters. In coastal rivers such as the Peace, Manatee, Little Manatee, Alafia, and Myakka, there are indications that fish may be most abundant during low river flow and fewest during heavy rainfall and runoff. There are positive correlations between (1) increasing river flows, decreasing salinities downstream, and the occurrence of essentially freshwater species in estuarine waters and (2) decreasing river flows, increasing salinities upstream, and the occurrence of both estuarine and marine fishes in essentially fresh water. Both findings imply that an increase in range, food resources, and available habitat correlates with river flow and salinity intrusion.

Water temperature partly controls the mass cyclic activities and seasonal patterns of occurrence and/or abundance of fishes in lotic waters of the study area. Densities and numbers of species are generally lowest during the winter months and highest during the spring and early summer. Most resident freshwater species spawn during slowly rising temperatures of spring and early summer; also at this time, river flows are lowest, potentially increasing the integrity of nesting sites and retention of the majority of the young within a suitable habitat.

Barring man-induced perturbations, most water quality parameters, including dissolved oxygen and pH, are of relatively minor importance in fish

Table 2.12. Occurrences and Relative Abundances of Fishes in Six Major Basins within Study Area

	River Basins					
Lotic Fishes	Peace	Myakka	Manatee	Little Manatee	Alafia	Hillsborough
Spotted gar	C	A	-	-	-	-
Longnose gar	C	P	-	O	-	C
Florida gar	C	P	P	-		C
Tarpon	R	-	-	-	-	-
Ladyfish	R	-	-	-	-	-
Bowfin	O	A	P	-	-	C
American eel	U	U	-	O	O	-
Gizzard shad	C	C	-	-	-	R
Threadfin shad	U	-	-	-	-	O
Redfin pickerel	R	-	P	-	O	
Chain pickerel	-	-	-	-	-	O
Golden shiner	O	P	P	R	R	O
Sailfin shiner	-	-	-	-	U	C
Ironcolor shiner	-	-	-	-	-	C
Coastal shiner	A	-	P	A	A	A
Blackspot shiner	A	-	-	-	-	-
Taillight shiner	C	C	P	-	-	-
Pugnose minnow	A	-	-	-	-	-
Bullhead minnow	O	-	-	-	-	-
Lake chubsucker	O	C	P	R	O	O
White catfish	C	-	-	-	-	C
Yellow bullhead	O	A	P	O	O	C
Brown bullhead	O	C	P		-	U
Channel catfish	C	C	-	-	-	C
Tadpole madtom	O	C	P	R	O	U
Walking catfish	R	-	-	-	-	P
Armored catfish	-	-	-	-	-	A
Pirate perch	R	-	P	-	O	O
Atlantic needlefish	R	-	-	-	-	
Bluefin killifish	O	C	P	U	-	C
Pigmy killifish	-	-	-	-	-	R
Seminole killifish	A	C	P	O	R	-
Golden topminnow	O	C	P	U	-	O
Lined topminnow	-	-	-	-	-	O
Flagfish	O	A	P	O	-	O
Starhead killifish	-	-	P	-	-	-
Sheepshead minnow	-	-	P	-	-	-
Goldspotted killifish	-	-	P	-	-	-
Rainwater killifish	-	-	P	P	-	-
Banded killifish	-	-	P	-	-	-
Mosquitofish	A	C	P	A	A	A
Least killifish	O	-	P	P	-	A
Sailfin molly	C	A	P	C	C	C
Brook siverside	C	C	P	C	U	A
Snook	C	-	-	-	-	-
Largemouth bass	C	A	P	O	C	C
Everglades pygmy sunfish	U	C	P	O	O	C
Okefenokee pygmy sunfish	-	-	-	-	-	C
Warmouth	O	C	P	O	O	C
Bluespotted sunfish	U	C	P	U	-	C
Redbreast sunfish	-	-	-	O	-	O
Dollar sunfish	O	P	-	O	O	C
Bluegill	A	A	P	O	O	A
Longear sunfish	-	C	-	-	-	-
Redear sunfish	C	P	-	U	O	C
Spotted sunfish	A	A	P	A	A	C
Black crappie	U	C	-	R	-	U
Brown darter	P	-	-	-	-	-
Swamp darter	O	C	P	O	O	C
Spotfin mojarra	-	P	-	-	-	-
Blackchin mouthbrooder	-	-	-	-	-	A
Mozambique mouthbrooder	-	-	-	-	-	A
Blue tilapia	C	-	-	-	-	R
Rio Grande perch	-	-	-	-	-	P
Striped mullet	C	A	-	C	P	-
Hogchoker	C	A	-	C	P	-

*Dames and Moore (1975)
Florida Department of Natural Resources (1976)
Cowell et al (1974)
Chapman (1973)
Texas Instruments (1977)

A = Abundant
C = Common
O = Occasional occurrences
U = Uncommon
R = Rare
P = Present, but with no indication of abundance

distribution or abundance in larger streams and rivers. These parameters appear to become critical only when water levels and/or circulation are low or seasonally interrupted and when water temperatures are high, especially in areas exhibiting heavy algal or aquatic macrophyte growth.

Five major habitat types comprise the range of environmental conditions in the majority of the study area's rivers and moderate to large streams:

- Sluggish runs are narrow portions having slow current, a relatively uniform substrate heavily silted with organic muck and detritus, and banks that are generally shallow-sloped and vegetated with trees and marginal emergent or floating aquatic vegetation. Fishes associated with this habitat are generally native to the stream and commonly include catfish, bluegill, spotted sunfish, warmouth, mosquitofish, seminole killifish, and largemouth bass.

- Riffle pools are generally formed by limestone outcroppings; have a substrate composed or rubble, gravel, and sand; and are commonly vegetated with shoreline aquatic macrophytes and attached algae. These pools are generally well-defined and relatively free of sediment; currents within them are fast (Ware 1969). Fish species commonly associated with riffle pools include sunfish (e.g., spotted sunfish, bluegill), largemouth bass, catfish, brook silverside, and killifish (e.g., seminole killifish).

- Sand-glide habitats, which occur most frequently in the lower reaches of rivers or streams, are generally formed in the tail of pools where sand accumulates because of reduced streamflow, permitting sediment deposition. This virtually pure sand substrate (except for occasional snags and logs) affords little cover or protection to fishes. Added protection, as well as food however, may be found in occasional concentrations of aquatic vegetation occurring along stream margins associated with the habitat (Ware 1969). Fishes commonly associated with sand-glide habitats generally include forage fish (e.g., killifish, livebearers, shiners) and both juvenile and adult predators (e.g., largemouth bass, white and channel catfish, and bream, or sunfish).

- Generally the prime environments for many of the fish species inhabiting river systems are two pool habitats, associated either with upstream areas or downstream areas; upstream pools are relatively small, with moderate current and abundant cover; downstream pools are longer, wider, sluggish, and silt-laden. In downstream pools, aquatic vegetation is generally emergent or floating and attached

> and consists of both aquatic macrophytes and algae. The number of fish species, which may vary within river habitat, is generally highest in these pool zones. Current-tolerant forms, e.g., bluegill, spotted sunfish, largemouth bass, and some catfishes occur in the small upstream pools; gars, channel catfish, and white catfish are common in the more sluggish downstream pools.

Distinct fish communities generally inhabit the nearshore and midstream waters of the rivers and large streams in the study area. The majority of the shorezone community generally comprises relatively large numbers of forage species and fewer young predators. Typical inhabitants include coastal and taillight shiner, seminole killifish, mosquitofish, brook silverside, redear, bluegill, spotted sunfish, and young-of-the-year and yearling largemouth bass. Younger sunfish, catfish, and largemouth bass remain part of the shorezone population until their increased size makes them less attractive to predators. Larger and older members of the same species encountered in their younger stages in the sheltered and often vegetated shore zone, as well as an increased number of higher carnivores (e.g., largemouth bass, channel catfish, white catfish, adult bream, and gar) occupy the more open waters of midstream areas.

Like many of the smaller ponds and sloughs dispersed throughout central Florida, a number of the smaller streams and creeks can be both a source of and a receptacle for fish species that may migrate or be transported to and from mainstem streams, rivers, or nearby lakes, ponds, or impoundments. Certain of the smaller streams are intermittent, imposing stringent environmental conditions on their inhabitants. The fish generally survive during low-water periods in small and often isolated pools where levels of dissolved oxygen often become a critical factor. However, these intermittent waters are usually populated by hardy species that include mosquitofish, least killifish, sailfin mollies, and small sunfishes such as the bluespotted and pygmy sunfish.

Creeks and streams connected with a more substantial water body generally possess both a more abundant and diverse fish fauna. Common constituents are gar, shiner, brook silverside, chubsucker, sunfish, bullhead, largemouth bass, and swamp darter. Importantly, these permanently flowing small creeks and streams, along with interconnecting canals and ditches, comprise the major access and dispersal routes available to the approximately 23 exotic fish species presently inhabiting the 7-county study area.

C. BAY AND ESTUARINE COMMUNITIES

The estuarine habitats of the study area include Tampa Bay, Charlotte Harbor, and the bays and inlets of the "Manasota" coast, which comprises the coastline of Manatee and Sarasota counties (Plate 5 in pocket). Since the estuarine areas of the Manasota coast are small compared with neighboring Tampa Bay and Charlotte Harbor but have features of both, this discussion focuses on the two larger estuarine systems. The Tampa Bay estuarine study area encompasses the five major embayments: Tampa Bay proper, Old Tampa Bay, Hillsborough Bay, Boca Ciega Bay, and Terra Ceia Bay. The Charlotte Harbor study area includes that portion of the Charlotte Harbor estuary north of Pine Island.

Although both the Tampa Bay and Charlotte Harbor estuarine systems have been well-studied, the Tampa Bay system has received the greater amount of attention. With few exceptions, biological studies of both systems have been component-oriented (e.g., red tide organisms, seagrasses, fishes, shellfishes, etc.); two recent publications, however, summarize existing information and generally describe both the Tampa Bay (Simon 1974) and Charlotte Harbor (Taylor 1974) estuaries. Notable studies also have been accomplished in response to the National Environmental Protection Act's (NEPA's) requirement for environmental impact assessments of extensive development activity in the estuaries; these include the environmental impact assessment for the Tampa Harbor Project (U.S. Army Corps of Engineers 1974) and investigations of the Charlotte Harbor estuary sponsored by General Development Corporation and Florida Power and Light. Continuing programs such as those conducted by the Florida Department of Natural Resources, as well as pollution monitoring programs by various state and federal agencies, are adding other dimensions to the growing knowledge of the two estuarine systems.

Table 2.13 summarizes some of the more pertinent hydrologic characteristics of Tampa Bay and Charlotte Harbor. Both estuaries are complex systems in which water-quality characteristics are influenced to a large degree by basic morphometry, a highly variable quantity and quality of freshwater influx, mixed tides, wind, and, of course, man's activities. The respective biotas of the two estuarine systems reflect the nature of the physicochemical

Table 2.13. Basic Hydrological Comparisons of Tampa Bay and Charlotte Harbor Systems*

	Tampa Bay Study Area	Charlotte Harbor Study Area
Surface area at mean high water Hectares (acres)	110,339 (272,643)	49,290 (121,793)
Volume at mean high water Cubic meters (acre-ft)	4.35×10^9 (3.53×10^6)	2.96×10^9 (1.73×10^6)
Mean depth** Meters (feet)	3.4 (11)	3.4 (11)
Diurnal tide range Meters (feet)	0.70-0.85 (2.3-2.8)***	0.58 (1.9)
Mean instantaneous freshwater influx**** Cubic meters (cubic feet) per second	4.52 (1595)	5.85 (2064)
Theoretical volume replacement interval***** Years	3.0	1.6

*Data primarily derived from McNulty et al (1972). Tampa Bay study area includes Tampa Bay, Hillsborough Bay, Old Tampa Bay, and Boca Ceiga Bay; data on Charlotte Harbor study area presumably encompasses the portion of the harbor north of Pine Island.

**Data from Simon (1974) and Taylor (1974) for respective estuaries.

***Represents range within various embayments of Tampa Bay system.

****Sum of mean flows of gaged streams discharging into respective study area; period of record for discharge data generally 1952-66.

*****Theoretical volume displacement interval calculated by dividing volume of water body by mean instantaneous freshwater influx. This is a theoretical concept and these figures are provided only to compare the relative effects of freshwater influx into Tampa Bay and Charlotte Harbor. The 3.0-year approximation for Tampa Bay agrees closely with a previous estimate of 2.8 years by Olson (1953). Although theoretical, these figures suggest that streamflow is a lesser factor in the flushing of Tampa Bay than in Charlotte Harbor.

complexities. As estuaries, both systems represent the interface or zone of intergrade between the freshwater environments inshore and the marine environment offshore. The biota of these embayments include the typical euryhaline (tolerant to a broad range of salinity) estuarine flora and fauna, as well as adventitious occurrences of stenohaline (tolerant to a narrow range of salinity) freshwater and marine forms.

1. Flora

a. Algae

The principal algal communities of the estuarine portions of the study area include phytoplankton, algae that grow in mats over the bottom substrate, forms that are attached to submerged or periodically submerged objects, and macroalgae, which occur as attached forms or, occasionally, as free-floating masses along the bottom. Table 2.14 lists the algal genera in the Tampa Bay and Charlotte Harbor study areas and indicates their relative abundances.

1) Phytoplankton

Characterizing the phytoplankton of a complex estuarine system is difficult because of the dynamics and basic heterogeneity of the system. Communities developing in the influence of discharge from contributing streams may vary considerably from those found in the more saline and less nutrient-rich waters in the middle reaches of the estuary. This may be further compounded by localized blooms of various algae. Despite notable variations in phytoplankton community characteristics within the Tampa Bay and Charlotte Harbor estuaries, the basic composition is similar for both and appears relatively stable. The diatoms *Skeletonema costatum, Asterionella japonica, Bellerochea malleus, Biddulphia regia, Rhizosolenia stolterfothii, Thalassionema nitzchioides*, and *Chaetocerus* spp. and the dinoflagellates *Ceratium hircus* and *Gonyaulax balechii* dominate the Tampa Bay study area (Dragovich et al 1965, Saunders et al 1967, Turner and Hopkins 1974), and the diatoms *Skeletoma costatum, Thalasiosira nana, T. levanderi, Rhizosolenia imbricata, R. hebatata, Chaetocerus breve, C. densum*, and *Asterionella japonica* and the dinoflagellates *Gymnodinium* spp., *Gonyaulax* spp., and *Ceratium hircus* dominate the Charlotte Harbor study area (Saunders et al 1967, USEPA 1974, Taylor 1974, TI 1977). The prevalent species reported in both estuaries is *Skeletonema costatum*. The phytoplankton communities of both study areas generally exhibit good diversity, although usually dominated by one or more forms. About 250 phytoplankters have been reported from Charlotte Harbor (TI 1977), and more than 100 species of diatoms and dinoflagellates have been reported from the Tampa Bay estuary (Steidinger et al 1967, Turner and Hopkins 1974, U.S. Army Corps of Engineers 1974).

The most salient difference between the phytoplankton characteristic of Tampa Bay and Charlotte Harbor is the substantial quantities of planktonic green and bluegreen algae and other typical freshwater forms during the wet season in Charlotte Harbor and the paucity in general of these forms in Tampa

Table 2.14. Occurrences and Relative Abundances of Algae in Charlotte Harbor and Tampa Bay Study Areas

Taxa	Relative Abundance: Charlotte* Harbor	Relative Abundance: Tampa** Bay
Cyanophyta		
Spirulina	O	A
Lyngbya	C	A
Oscillatoria	C	A
Calothrix	C	C
Microcoleus	R	C
Anacystis	-	O
Schizothrix	O	-
Phormidium	O	-
Microcystis	O	-
Agmenellum	U	-
Aphanocapsa	U	-
Anabaena	U	R
Porphyrosiphon	U	-
Trichodesmium	U	U
Chroococcus	R	-
Aphanizomenon	R	-
Nodularia	R	-
Chlorophyta		
Ulva	O	A
Udotea	-	C
Penicillus	-	C
Boodleopsis	-	C
Chaetomorpha	-	C
Cladophora	-	C
Rhizoclonium	O	C
Enteromorpha	O	C
Halimeda	-	C
Carlerpa	-	O
Codium	-	O
Avrainvillea	-	O
Heteromastix	O	-
Chlamydomonas	U	-
Spermatozoopsis	U	-
Ankistrodesmus	U	-
Scenedesmus	U	-
Carteria	R	-
Eudorina	R	-
Platymonas	R	-
Gleocystis	R	-
Kirschneriella	R	-
Oocystis	R	-
Pediastrum	R	-
Chodatella	R	-
Echinosphaerella	R	-
Closterium	R	-
Staurastrum	R	-
Monostroma	R	-
Protoderma	R	-
Entocladia	R	-
Phaeophila	R	-
Euglenophyta		
Euglena	R	-
Phaeus	R	-
Chrysophyta		
Vaucheria	-	C
Prymnesiales (unspecified)	U	-
Chrysameba	R	-
Mallomonas	R	-
Silicoflagellates		
Distephanus	O	-
Dictyocha	R	-
Bacillariophyta		
Skeletonema	A	A
Chaetocerus	A	A
Asterionella	A	A
Biddulphia	A	C
Thallasiosira	A	C
Rhizosolenia	A	C
Thallasionema	O	A
Nitzchia	C	C
Navicula	C	O
Bellerochea	R	A
Coscinodiscus	C	O
Leptocylindrus	U	C
Cerataulina	O	C
Fragilaria	C	-
Achnanthes	C	-
Cocconeis	C	-
Bacillaria	R	C
Eupodiscus	R	C
Tropidoneis	U	C

Taxa	Relative Abundance: Charlotte* Harbor	Relative Abundance: Tampa** Bay
Bacillariophyta Cont.		
Melosira	O	O
Corethron	O	O
Pleurosigma/Gyrosigma	O	O
Amphora	O	O
Amphiprora	O	O
Cyclotella	O	U
Paralia	R	O
Opephora	O	-
Gyrosigma	U	O
Striatella	R	O
Grammatophora	U	O
Hemiaulus	R	O
Thalassiothrix	O	O
Bacteriastrum	U	U
Ditylum	R	U
Synedra	U	-
Mastogloia	U	-
Pinnularia	U	-
Dimerogramma	U	-
Lithodesmium	U	R
Lauderia	R	U
Climacodium	U	U
Streptotheca	U	U
Microsiphona	R	-
Actinoptychus	R	R
Coscinosira	R	-
Hemidiscus	R	-
Diatoma	R	-
Licmophora	R	-
Eunotia	R	-
Stephanodiscus	R	-
Podocystis	R	-
Cymatosira	R	-
Campyloneis	R	-
Neidium	R	-
Gomphonema	R	-
Cymbella	R	-
Diploneis	R	-
Surirella	R	-
Campylodiscus	R	-
Terpsinoe	R	-
Tabellaria	R	-
Rhabdonema	R	-
Epithemis	R	-
Rhopolodia	R	-
Eupodiscus	-	R
Triceratium	-	R
Guinardia	R	R
Pyrrophyta		
Gymnodinium	A	C
Gonyaulax	C	A
Ceratium	O	A
Peridinium	O	C
Prorocentrum	R	O
Ornithocercus	-	U
Dinophysis	R	U
Exuviella	R	-
Amphidinium	R	-
Polykrikos	-	P
Phaeophyta		
Cladosiphon	-	C
Spacelaria	-	C
Rosenvingea	-	C
Ascocyclus	-	O
Bachelotia	-	O
Ectocarpus	-	O
Giffordia	-	O
Dictyota	-	O
Stilophora	-	O
Ectocarpales (unspecified)	R	-
Rhodophyta		
Gracilaria	A	A
Spyridia	-	A
Hypnea	-	A
Laurencia	-	C
Fosliella	-	C
Acanthophora	-	C
Centroceras	-	C
Bostrychia	-	C
Polysiphonia	R	O
Gelidium	-	O
Agardhiella	-	O

*Saunders et al (1967)
Humm (1973)
U.S. Environmental Protection Agency (1974)
Florida Department of Natural Resources (1975)
Texas Instruments Incorporated (1977)

**Olson (1953)
Phillips (1960, 1963)
Dragovich et al (1965)
Federal Water Polution Control Administration (1969)
Humm (1973)
Dawes (1974)
Turner and Hopkins (1974)
Steidinger (19[illegible])

A = Abundant
C = Common
O = Occasional occurrences
U = Uncommon
R = Rare
P = Present, but with no indication of abundance

Bay. The bluegreens *Microcystis* and *Agmenellum* and the green *Heteromastix* (volvocales), all considered freshwater forms, were abundant in plankton from Charlotte Harbor during June through August, then declined sharply as Peace River flows diminished (TI 1977). This difference in the two estuarine systems is a manifestation of the inordinant influence of the large seasonal discharge of the Peace River into Charlotte Harbor and the considerably higher influx-to-volume ratio of Charlotte Harbor compared with Tampa Bay.

The most notorious phytoplankter is a small dinoflagellate, *Gymnodinium breve*; periodically, the population of this minute single-cell alga blooms to large concentrations, creating the dreaded red tide of the Florida west coast. There is evidence that the blooms are in some way triggered by periods of unusually large surface runoff and high discharges of local streams. Much of the available information on the ecology and nuisance aspects of this species is summarized in Section 3.

Phytoplankton are important primary producers in estuaries, particularly in the deeper areas where benthic algae and seagrasses are limited by diminished sunlight. In a 1962-63 productivity study of Tampa Bay, May (1966) found that an average of 213.4 grams of carbon per square meter (1880 pounds per acre) of dry organic matter was produced annually in the bay. Seasonally, production was maximum during July-October and minimum in the spring; locally Hillsborough Bay exhibited the maximum production and offshore areas in the Gulf of Mexico had the lowest. During a 1964-67 study by the National Marine Fisheries Service, phytoplankton gross annual productivity in Tampa Bay was estimated to be between 134 and 427 grams of carbon per square meter (2766-3762 pounds per acre) (McNulty et al 1970). Steidinger (1973) made a similar estimate of 410 grams of carbon per square meter (3533 pounds per acre) for the Tampa Bay complex and indicated that this amount of production is as high or higher than that of other parts of the world. Information on phytoplankton production within Charlotte Harbor is more limited. Taylor (1974) provides an estimate of about 25 grams of carbon per square meter per year (220 pounds per acre per year) based on data of May (1966) and Steidinger (1973). Although an order of magnitude lower than values reported for Tampa Bay, this amount of productivity compares favorably with estimates from highly productive fresh and marine waters of the world. In view of the similarities in phytoplankton densities and composition in Tampa Bay (Turner and Hopkins 1974) and Charlotte Harbor (TI 1977), it appears that the 25 grams of carbon per square meter per year estimate for Charlotte Harbor might be low, particularly for areas in northern portions of the estuary.

Although spatial heterogenity of productivity and standing crop exists throughout the Tampa Bay and Charlotte Harbor estuaries, there is a common pattern of declining phytoplankton abundance with declining nutrient levels from upper to lower regions of the two estuaries (U.S. Army Corps of Engineers 1974, TI 1977). Spatial patterns of phytoplankton numbers, chlorophyll *a*, and biomass in Tampa Bay are especially evident in the data summarization by Turner and Hopkins (1974) (Table 2.15). TI (1977) noted a similar phytoplankton pattern in Charlotte Harbor. Phytoplankton biomass is greatest where nutrient-rich stream waters initially mix with saline harbor waters; it then declines progressively as nutrient concentrations and phytoplankton numbers become smaller away from the major nutrient sources. However, the high standing crop noted throughout Hillsborough Bay is a function of nutrient enrichment from domestic sewage effluent as well as from the two rivers, the Alafia and the Hillsborough.

Temporal patterns in phytoplankton productivity appear somewhat different for Tampa Bay and Charlotte Harbor. Seasonal peaks in productivity occur in all areas of Tampa Bay in spring and late summer, with productivity consistently highest in Hillsborough Bay (Kelly and Johnson 1967). No time series productivity measurements for Charlotte Harbor have been reported, but numerical density data (TI 1977) indicate a single peak of production in the spring near the end of the dry season (May) in Charlotte Harbor proper and two peaks — one in March and one in October — in the Peace River estuary. However, observations for Charlotte Harbor are based on only 10 months of data.

2) Benthic Mat Algae

The benthic algal mat community consists of a variety of principally filamentous algae that grow in a mat conformation over the bottom substrate in shallow water. This type of community is prevalent in the intertidal areas of mangrove swamps and tidal marshes where the mats develop on mud. A description

Table 2.15. Tampa Bay System Phytoplankton Densities, Chlorophyll *a* Values and Biomass Values Averaged by Area by Season, Fall 1969-Summer 1971*

		Fall 1969	Winter 1970	Spring 1970	Summer 1970	Fall 1970	Winter 1971	Spring-Summer 1971	Mean
Phytoplankton Density (10^6 cells/liter)	Old Tampa Bay	2.80	0.66	0.78	0.27	0.45	0.95	2.05	1.13 [1.14]†
	Hillsborough Bay	1.80	1.89	1.17	0.42	1.40	0.65	1.10	1.32 [1.20]
	Tributaries of Hillsborough Bay	7.26	2.07	1.88	0.73	-	-	-	2.98
	Upper Tampa Bay	2.15	0.07	1.36	0.13	-	-	-	0.93
	Mid Tampa Bay	1.85	1.00	0.78	0.13	0.10	0.10	1.30	0.94 [0.75]
	Little Manatee River	1.50	3.16	0.37	0.90	-	-	-	1.48
	Entrance of Tampa Bay	3.24	0.30	0.18	0.30	0.60	0.40	0.30	1.00 [0.76]
	Terra Ceia Bay	1.99	0.33	0.35	0.25	-	-	-	0.73
	Boca Ciega Bay	2.80	0.50	0.78	0.48	-	-	-	1.14
	Pinellas County Shoreline	4.07	1.77	0.30	0.23	-	-	-	1.59
	Manatee River	8.88	0.55	0.55	0.43	-	-	-	2.60
	Seasonal Average	3.48	1.18	0.77	0.39	-	-	-	
Chlorophyll a (milligrams/cubic meter)	Old Tampa Bay	16.48	3.55	5.35	25.61	2.32	6.43	7.82	13.00 [9.79]
	Hillsborough Bay	31.59	56.47	21.99	41.74	3.43	48.61	2.69	37.95 [29.50]
	Tributaries of Hillsborough Bay	27.17	16.96	73.52	32.35	-	-	-	37.50
	Upper Tampa Bay	21.30	19.29	2.83	21.14	-	-	-	16.26
	Mid Tampa Bay	4.82	5.62	11.38	16.08	1.67	163.60**	0.14	9.48 [6.61]
	Little Manatee River	10.67	5.33	10.38	32.62	-	-	-	14.75
	Entrance of Tampa Bay	3.83	3.12	1.62	6.05	1.16	4.06	0.52	3.66 [2.91]
	Terra Ceia Bay	19.68	2.50	13.65	16.69	-	-	-	13.13
	Boca Ciega Bay	12.54	6.74	7.35	16.37	-	-	-	10.75
	Pinellas County Shoreline	11.21	6.26	6.70	23.45	-	-	-	11.90
	Manatee River	16.21	3.40	8.69	20.97	-	-	-	12.32
	Seasonal Average	16.00	11.75	14.86	23.09	-	-	-	
Biomass (grams · carbon/cubic meter)	Old Tampa Bay	1.240	3.616	0.594	0.750	0.541	0.488	1.952	1.550 [1.312]
	Hillsborough Bay	2.986	1.887	0.967	1.204	0.112	6.823	4.825	1.761 [2.686]
	Tributaries of Hillsborough Bay	0.508	1.061	1.984	0.207	-	-	-	0.940
	Upper Tampa Bay	1.845	5.124	0.399	0.473	-	-	-	1.960
	Mid Tampa Bay	0.162	0.440	1.152	0.188	0.443	0.491	0.523	0.486 [0.486]
	Little Manatee River	0.898	0.326	0.804	0.814	-	-	-	0.710
	Entrance of Tampa Bay	0.238	0.163	0.204	0.176	0.180	0.025	0.025	0.196 [0.145]
	Terra Ceia Bay	1.073	0.383	0.317	0.664	-	-	-	0.609
	Boca Ciega Bay	0.780	0.725	0.523	3.814	-	-	-	1.462
	Pinellas County Shoreline	0.787	0.184	0.429	1.548	-	-	-	0.732
	Manatee River	0.221	0.300	0.407	0.710	-	-	-	0.410
	Seasonal Average	0.977	1.290	0.714	0.959	-	-	-	

*Modified from Turner and Hopkins 1974.

†Means computed for areas having seven periods of measurement are in brackets and should be compared only with other similarly bracketed values. All other mean values computed for the various areas are based on first four seasonal samplings, Fall 1969-Summer 1970.

**Based on phytoplankton density estimates and biomass for same sample; value presumably erroneous and thus omitted from mean calculation.

of the typical mangrove community in Tampa Bay (Dawes 1974) included the filamentous algae (*Cladophora, Chaetomorpha, Boodleopsis, Vaucheria, Centroceras*) found matted together on mud among the mangroves. A similar description of saltmarsh communities of Tampa Bay (Dawes 1974) refers to algal mat development on the mud among the saltmarsh plants; principal species in this community are *Anacystis, Microcoleus, Oscillatoria, Cladophora, Chaetomorpha, Centroceras,* and *Vaucheria*. The algal mat communities are ecologically important because they contribute significant amounts of organic matter to the substrate and trap finer soil particles and plant debris; as the substrate level increases less saltwater-tolerant species (e.g., white mangrove and buttonwood) may germinate (Dawes 1974). In submerged areas, these mat communities may become dislodged from the substrate, be carried to the surface by entrapped air bubbles and become a food source, particularly for mullet (Phillips 1963). Locally, the floating mats are called mullet gunk.

The development of the saltwater benthic mat community is similar to that described for freshwater: small patches of bluegreen algal scum coalesce through marginal expansion, forming a mat of algae, and individual filaments bound together by gelatinous secretions comprise a relatively tough surface layer. The surface layer is composed of brilliantly colored blue-green algae — either *Spirulina subsalsa* or *Lyngbya majuscula*, depending on the habitat (Phillips 1963); below the surface layer is a layer of dead or dying trichomes of the algae, in which nematodes, protozoa, and bacteria are most active; and below the latter, mud particles of the substrate are consolidated into the mass. Thousands of diatoms, many crustaceans, and phytoplankton occur throughout the mat. These same communities are known also to develop over the leaves of seagrasses, reducing the amount of sunlight reaching the leaves and adding considerable weight to the leaves.

3) Attached Algae

Commonly referred to as aufwuchs, attached algal communities are important to the ecology of an estuary. The composition of these communities may vary considerably with physicochemical factors such as salinity, turbidity, current or wave action, substrate, etc. Common substrates supporting attached algal communities are seawalls, pilings, mangrove roots, seagrass leaves, shells, and rocks. The location of the substrate relative to water depth is important to the development of the attached algal communities. Dawes (1974) provides a convenient community zonation classification:

- A supralittoral zone (spray zone above high tide)
- A littoral zone (region of tidal fluctuation)
- A sublittoral zone (below lowest tide)

According to Dawes (1974), the supralittoral zones of the study area probably contain an association of bluegreen algae, especially *Microcoleus* and *Calothrix*, which forms black to brownish regions on the exposed substrate. This association, characteristic of the spray zone, is usually among or just above the barnacles. This bluegreen association grades into a *Centroceras* association in the littoral zone.

The attached algae community in the littoral zone is characterized by filamentous turf algae (*Bryopsis*, *Ceramium*, *Chaetomorpha*, *Bostrychia*), as well as other larger forms (*Acanthophora* and *Hypnea*) (Dawes 1974). The largest variety of attached algae is found in the *Caulerpa* (*prolifera*, *mexicana*, *racemosa*) associations of the lower littoral zone. *Hypnea*, *Cladophoropsis*, *Gracilaria*, *Chaetomorpha*, *Spyridia*, *Pterocladia*, *Cladophora*, and many other species are present in this zone. As the *Caulerpa* association extends into the sublittoral zone, water turbidity causes a reduction in the variety and condition of species. At depths of approximately 2 meters (6.5 feet), only occasional individuals of *Padina*, *Sargassum*, *Ulva*, *Pterocladia*, and *Caulerpa* are found.

A vertical zonation in attached algae is apparent also on the pneumatophores of the black mangrove (Dawes 1974). The uppermost portion of the pneumatophores (corresponding to the supralittoral zone) has bluegreen algae, the intermediate region (upper littoral) has *Rhizoclonium* and *Entomorpha*, and the lower littoral zone has *Bostrychia* and *Caloglossa*. *Ulva*, *Monostroma*, *Centroceras*, and *Polysiphonis* are common epiphytes on prop roots of the red mangrove.

Some of the common epiphytes on the seagrasses of the study area are *Champia*, *Lomentaria*, *Polysiphonia*, *Acrochaetium*, *Fosliella*, *Hypnea*, *Spyridia*, *Cladosiphon*, *Ectocarpus*, and *Cladophora* (Dawes 1974).

Most of the preceding information on attached algal communities is relative to the Tampa Bay study area, and it is reasonable to assume that similar community types would be common also to the Charlotte Harbor estuary because of proximity and similar vascular plant growth.

4) Benthic Macroalgae

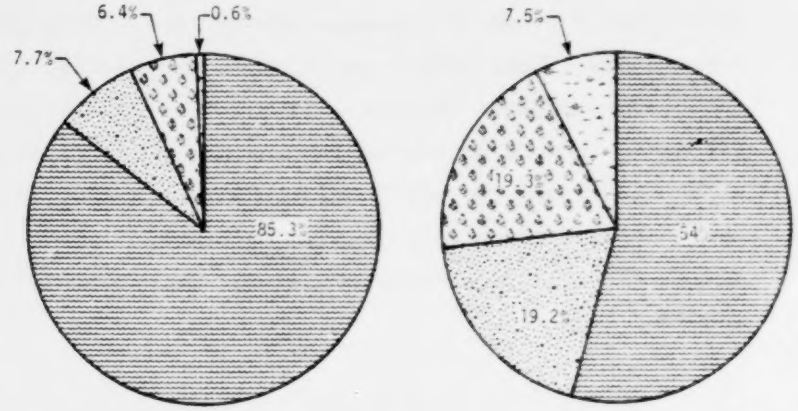
The most prominent benthic macroalgae reported from the study area are *Gracillaria verrucosa*, *Hypnea musciformis*, and *Spyridia filamentosa*; all are unattached and are near the bottom because of their density (Phillips 1960).

Because of nutrient enrichment, populations of two forms of benthic algae have occasionally grown to nuisance proportions: *Gracilaria*, a problem in Hillsborough Bay (FWPCA 1969), and *Ulva*, a troublesome species in Old Tampa Bay (U.S. Army Corps of Engineers 1974). The *Gracillaria* nuisance problem is discussed in more detail in subsection C. No reports of nuisance benthic algae conditions for the Charlotte Harbor estuary have been found; in fact, there appears to be only limited information about the benthic algae of this system (Florida Department of Natural Resources 1975a, USEPA 1974, Godcharles and Jaap 1973).

b. Vascular Plants

The vascular aquatic flora of the estuarine portions of the study area may be categorized into three basic community types: seagrass beds, mangrove swamps, and salt marshes. All three communities play important roles in the overall ecology of both the Tampa Bay and Charlotte Harbor estuaries. The relative areal extent of each within the two estuaries is shown in Figure 2.1. Since these two estuaries are in close proximity, it would be assumed that, in their natural state, vegetation patterns would be similar for the two. Coastal development, however, has been extensive in the Tampa Bay area, severely altering the natural vegetation of that estuary, as is readily apparent in the illustration. The extent of man's encroachment on the natural vegetation of the estuarine study areas is indicated in Table 2.16; however, the data are 10 years old, so undoubtedly, the extent of filled and drained areas is now considerably greater.

Table 2.17 lists aquatic vascular plants occurring in the two estuarine study areas and indicates their abundances. While not exhaustive, the taxa list does represent species reported in investigations relative to the aquatic ecology of the Tampa Bay and Charlotte Harbor estuaries. The discussion that follows emphasizes hydric forms. Information on the landward vegetation that occurs along the edges of the two estuaries is discussed in Volume VI (Section 5).



	Tampa Bay Hectares (Acres)	Charlotte Harbor Hectares (Acres)
▤ Unvegetated (open water)	102,308 (232,519)	26,340 (65,849)
▒ Submerged vegetation (seagrasses and benthic algae)	8,353 (20,882)	9,353 (23,383)
▨ Mangroves	7,006 (17,514)	9,390 (23,474)
░ Tidal marsh	691 (1,728)	3,635 (9,087)
Total area at mean high water	109,057 (272,643)	48,717 (121,793)

Figure 2.1. Aquatic Vegetation Patterns for Tampa Bay and Charlotte Harbor (McNulty et al 1972)

Table 2.16. Filled and Drained Areas of Tampa Bay and Charlotte Harbor Study Areas*

Areas	Filled Areas			Drained Tidal Marsh
	Emergent Spoil Banks Hectares (Acres)	Causeways Hectares (Acres)	Housing, Industry Others Hectares (Acres)	Hectares (Acres)
Tampa Bay				
Tampa Bay	30 (75)	304 (760)	912 (2280)	1512 (3780)
Hillsborough Bay	38 (95)	16 (40)	1007 (2517)	577 (1442)
Old Tampa Bay	0 (0)	264 (660)	416 (1040)	1321 (3302)
Boca Ciega Bay	0 (0)	31 (77)	1199 (2997)	423 (1058)
Total	68 (170)	615 (1537)	3534 (8834)	3833 (9582)
Charlotte Harbor	20 (50)	47 (118)	212 (530)	2780 (6950)

*McNulty et al (1972).

Table 2.17. Aquatic Vascular Plants and Relative Abundances in Charlotte Harbor and Tampa Bay Study Areas

	Charlotte Harbor	Tampa Bay
Turtle grass *(Thalassia testudinum)*	A	A
Shoal grass *(Halodule wrightii)*	A	A
Widgeon grass *(Ruppia maritima)*	A	A
Marsh grass *(Spartina spp.)*	A	A
Manatee grass *(Syringodium filiforme)*	C	A
Halophila *(Halophila engelmanni)*	C	A
Red mangrove *(Rhizophora mangle)*	A	A
Black mangrove *(Avicennia germinans)*	A	A
White mangrove *(Laguncularia racemosa)*	C	C
Buttonwood *(Conocarpus erecta)*	C	C
Rush *(Juncus roemerianus)*	A	P
Salt grass *(Distichlis spicata)*	P	P
Saltwort *(Batis maritima)*	P	P
Glasswort *(Salicornia virginica)*	P	P
Salt grass *(Sporobolis spp.)*	P	P
Brazilian pepper tree *(Shinus terebinthifolius)*	P	P
Mangrove leatherfern *(Acrostichum danaefolium)*	P	P
Smartweed *(Polygonum densifolum)*	O	-
Pickerel-weed *(Pontedaria spp.)*	O	-
Water cress *(Nasturtium officinale)*	O	-
American frog's-bit *(Limnobium spongia)*	O	-
Cattail *(Typha spp.)*	U	-
Pursh *(Callitiche heterophylla)*	U	-
Pondweed *(Potamogeton foliosus)*	U	-

*Phillips (1960)
Godcharles (1971)
Ecoimpact Inc. (1973)
Godcharles and Jaap (1973)
Dawes (1974)
U.S. Army Corps of Engineers (1974)
Flordia Department of Natural Resources (1975)
Van Breedveld (1975)
Texas Instruments (1977)

A = Abundant
C = Common
O = Occasional occurrences
U = Uncommon
R = Rare
P = Present, but with no indication of abundance

1) Seagrass Beds

The submerged vegetation of the estuarine study areas consists of more than 200 species of algae and five species of seagrass (Phillips 1960, Dawes 1974, Simon 1974, Taylor 1974). The seagrasses, which are the most conspicuous floristic feature, are turtle grass *(Thalassia)*, shoal grass *(Diplanthera)*, manatee grass *(Syringodium)*, widgeon grass *(Ruppia)*, and *Halophila*.

The ecological value of the seagrass communities is well-documented. Some of the more important environmental roles are substrate stabilization, primary productivity, provision of habitat, and structural basis for development of a diverse and productive community. On the economic as well as ecologic side, seagrass beds serve as important nursery areas for many of the economically important fishes and shellfishes, providing abundant food supplies and refuge from predators.

Seagrass beds in the Charlotte Harbor study area are distributed continuously along both east and west shorelines, penetrating to a depth of approximately 2 meters (6.5 feet) (McNulty et al 1972), and are composed of various proportions of turtle grass, shoal grass, and *Halophila* (TI 1977). Widgeon grass and shoal grass generally predominate in the less saline waters of the northern portion of the estuary. In the Tampa Bay estuary, seagrass beds appear restricted to small patches in Old Tampa Bay and Tampa Bay proper and to larger patches in Boca Ciega Bay and the area near the mouth of the Tampa Bay complex.

The principal factors governing location and composition of seagrass beds in the study area are water transparency, salinity, temperature, and depth relative to tide. Transparency is always an important factor in aquatic flora development since it influences the amount of sunlight available to the plant for photosynthesis. Because the five seagrasses vary in their salinity tolerance, the salt content of the water influences to a large degree the community composition of the beds. Dawes (1974) indicates that widgeon grass is basically a freshwater form; McNulty et al (1972), however, observe that it is euryhaline in salinities of 5-50 parts per thousand but more common in the low range. Shoal grass generally is common in salinities of 12-20 parts per thousand but may occur at higher salinities. Manatee grass and *Halophila* usually occur in salinities of 20-40 parts per thousand and turtle grass at 25-40 (Dawes 1974). A vertical zonation in composition is common in shallow estuaries and is related to tides (Phillips 1960, McNulty et al 1972). Figure 2.2 is a schematic illustrating the zonation patterns of seagrass communities in Tampa Bay.

Low temperature extremes are important to the relative abundances of the various seagrasses in the beds. When an extensive winter leaf kill of manatee grass and shoal grass occurred in Old Tampa Bay (Phillips 1960), widgeon grass became more abundant; apparently widgeon grass is relatively more abundant in winter and spring than in summer and autumn because of lower abundances of the other grasses during winter. Winter leaf kill probably is a common phenomenon that often severely affects turtle grass, manatee grass, and shoal grass in the study area.

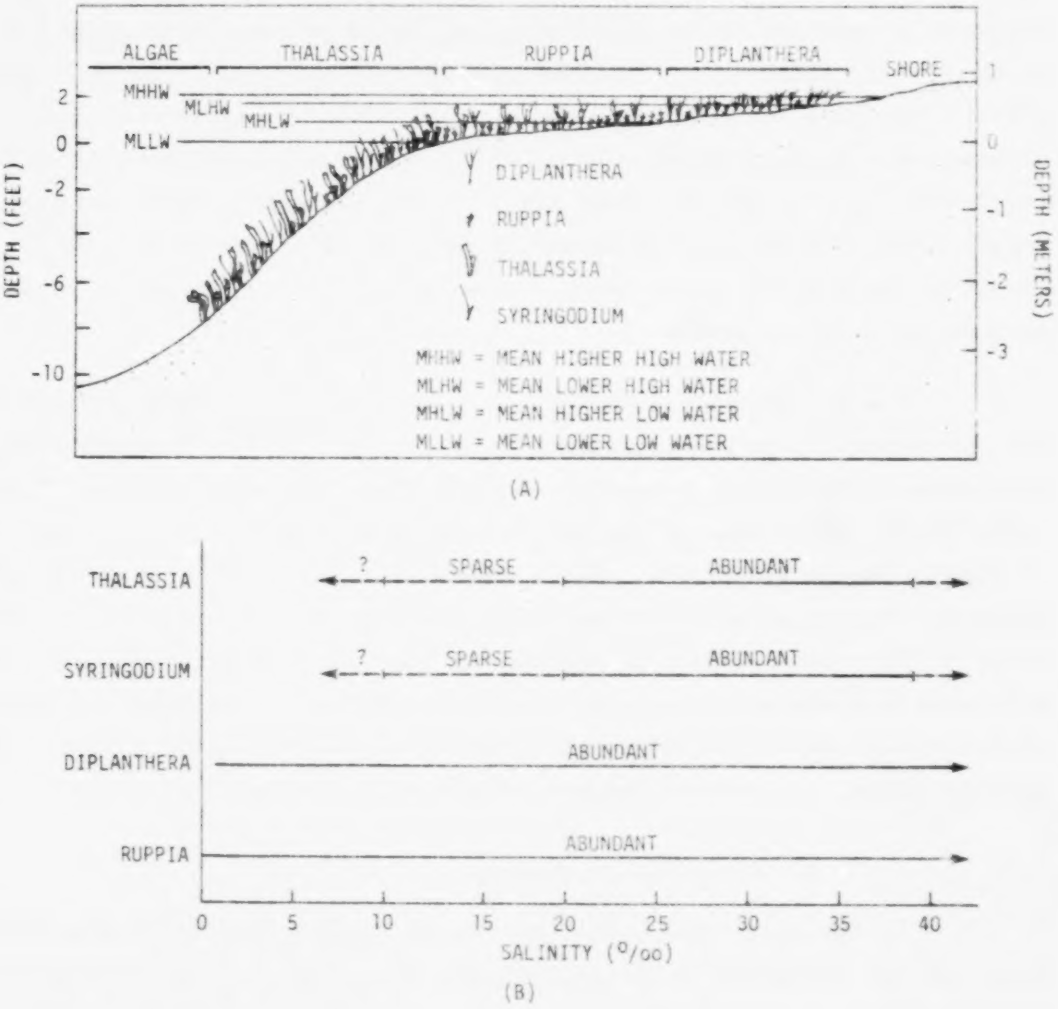

ALGAE
THALASSIA
RUPPIA
DIPLANTHERA
SHORE
MHHW
MLHW
MHLW
MLLW
DIPLANTHERA
RUPPIA
THALASSIA
SYRINGODIUM
MHHW = MEAN HIGHER HIGH WATER
MLHW = MEAN LOWER HIGH WATER
MHLW = MEAN HIGHER LOW WATER
MLLW = MEAN LOWER LOW WATER
DEPTH (FEET)
2
0
-2
-6
-10
DEPTH (METERS)
1
0
-1
-2
-3
(A)
THALASSIA
? SPARSE ABUNDANT
SYRINGODIUM
? SPARSE ABUNDANT
DIPLANTHERA
ABUNDANT
RUPPIA
ABUNDANT
0
5
10
15
20
25
30
35
40
SALINITY (°/oo)
(B)

Figure 2.2. Schematic of Zonation of Seagrasses in Shallow Waters of Tampa Bay (A) and Their Salinity Preferences and Tolerances (B) (McNulty Lindall, and Sykes 1972)

2) Mangrove Communities

Mangrove swamps are the major form of littoral zone vegetation along the west coast of Florida from Tampa Bay southward. Dominants, in order of abundances, are red mangrove, black mangrove, white mangrove, and buttonwood (Dawes 1974, McNulty et al 1974, Taylor 1974). One of the most characteristic features of the mangrove communities is a rather pronounced zonation relative to water levels: red mangroves generally occur at the level of low tide or slightly deeper to approximately the mean high water mark; landward, the red mangrove is replaced by the black mangrove, which is then followed by a mixed stand of white mangrove and buttonwood (McNulty et al 1972, Humm 1973, Taylor 1974). The Tampa Bay study area has more than 7,080 hectares (17,500 acres) of mangrove community (McNulty et al 1972), with stands extensive along Manatee County's shoreline and around parts of Old Tampa Bay. There are approximately 9,510 hectares (23,500 acres) of mangrove in Charlotte Harbor, the most extensive areas being at the mouth of the Peace River and along the estuary's eastern and northern shores.

The ecological importance of the mangrove communities includes primary production, land stabilization, and structural basis for animal community development (Davis 1940, Humm 1973, Carlton 1974, U.S. Army Corps of Engineers 1974, Taylor 1974). One of the most important ecological contributions is that of organic matter production. Heald (1971) reports that a mangrove forest of southwest Florida annually produces 876 grams per square meter (7,779 pounds per acre) of dry organic matter in the form of leaves and twigs which then enter the estuarine food chain; Taylor (1974) uses this figure to estimate that mangroves annually yield about 184,000 tons of dry organic matter to the Charlotte Harbor estuary. (This is discussed further in Volume VI, Section 5.)

3) Saltmarsh Communities

In the study area, tidal marshes occur as a transition zone between mangroves and freshwater marshes; northward from Tampa Bay, they become the predominant plant community along the entire Gulf Coast. In the Tampa Bay study area, there are approximately 700 hectares (1,728 acres) of tidal marshes (McNulty et al 1972), which are generally limited to areas along the Manatee and Little Manatee rivers and near Oldsmar in Old Tampa Bay (U.S. Army Corps of Engineers 1974). The Charlotte Harbor study area has about 3,678 hectares (9087 acres) of tidal marshes (McNulty et al 1972), the more extensive ones being near the mouths of the Peace and Myakka rivers and along the eastern shore of the harbor.

Black rush *(Juncus)* dominates the tidal marshes of the study area, although several species such as marsh grasses (smooth and slender cordgrass), saltgrass, glasswort, and saltwort may be locally abundant (McNulty et al 1972, Dawes 1974, U.S. Army Corps of Engineers 1974). Smooth cordgrass, *Juncus* marsh, salt flats, and salt barrens are the four discernible major ecological zones (McNulty et al 1972). Smooth cordgrass extends seaward beyond the level of high tide and is replaced on higher ground by black rush. The third zone (sand flats) is vegetated principally by slender cordgrass and salt grass. In the fourth zone (salt barrens), the only conspicuous plant is perennial glasswort (Humm 1973, McNulty et al 1972, U.S. Army Corps of Engineers 1974).

The important ecological roles played by the salt marshes are similar to those of the mangrove communities, i.e., production of organic matter, land stabilization, and provision of habitat. Not only are they extremely important as nursery areas for the majority of economically important fishes and shellfishes, but they are among the most productive plant communities of the world, with annual production of dry organic matter approaching 2 kilograms per square meter (22,000 pounds per acre) (Gosselink et al 1974). According to estimates, as much as 45 percent of this production may be flushed into the open waters of the adjacent estuary [along the coast of Georgia in this case (Teal 1962)] to enter the estuarine food web. Taylor (1974), using a 2 kilogram per square meter annual production estimate, projected that the dry organic matter production by marsh vegetation in the Charlotte Harbor estuary amounted to approximately 167,400 metric (186,000 short) tons per year.

2. Fauna

a. Zooplankton

Zooplankton communities of estuaries comprise a wide variety of micro- and macroinvertebrates as well as the eggs and larvae of fishes. Invertebrate forms will be discussed here, and the early life stages of fishes will be discussed along with fish species of the estuaries.

In the most extensive investigation of zooplankton of Charlotte Harbor (TI 1977), two mesh sizes (153 and 505 microns) were used to yield both micro- and macrozooplankton. A similar study of the zooplankton of Tampa Bay (Kelly and Dragovich 1967) used a 1027-micron mesh net, which effectively samples macrozooplankters only; so information on the microzooplankton of the bay is limited (Hopkins 1973, TECO 1973).

Zooplankters reported in the Tampa Bay and Charlotte Harbor study areas are listed, along with their relative abundances in Table 2.18.

Major macrozooplankton of the Tampa Bay estuary (Dragovich and Kelly 1964) are a sergestid shrimp *(Lucifer faxoni)*, larval porcellanids, and larval brachyurans. Less abundant but widely distributed and frequently occurring forms are copepods (principally *Labidocera aestiva*), advanced postlarvae of caridean shrimp (primarily *Palaemonetes*, *Periclimines*, *Alpheus*, *Synalpheus*, *Tozeuma*, *Hippolysmata*, and *Latreutes*), postlarval mud shrimp (*Upogebia* and *Callianassa*), larval mantis shrimp (probably *Squilla empusa*), amphipods (suborders Caprillidea, Gammaridea, and Hyperiidea), isopods (*Aegathoa*), penaeid shrimp (larvae of *Sicyonia* spp., *Trachypeneus* spp., and *Penaeus duorarum*) appendiculariids (*Appendicularia* and *Oikopleura*), cheatognaths (*Sagitta*), and polychaete larvae (principally terebellids and spionids). Greatest concentrations of macrozooplankton apparently are in upper and central Tampa Bay, central Old Tampa Bay, Hillsborough Bay, and approximately 6.5 kilometers (4 miles) offshore. Seasonally, 5 percent of the total macrozooplankton volume (ranging from 0.5 to 92 milliliters per 35 cubic meters and averaging 7 milliliters) occurred in winter, 18 percent in spring, 52 percent in summer, and 25 percent in fall.

In Charlotte Harbor (TI 1977), relative abundances of microzooplankton indicate a comparatively stable community composition dominated by copepods (primarily *Oithona* and *Acartia*) that rarely compose less than 50 percent of the total density; Cirripedia (barnacles) larvae are always present but apparently never dominant. The composition of the macrozooplankton appears far less stable and is dominated to a large extent by meroplankton. Decapod larvae (primarily crab and shrimp larvae) dominate during the period of higher salinities (January-April). During May-July, holoplankton such as the cladocerans *Evadne* and *Penilia* are dominant. Decapod larvae again dominate during August-October; codominants

Table 2.18. Occurrences and Relative Abundances of Zooplankton from Charlotte Harbor and Tampa Bay*

Zooplankton	Charlotte Harbor	Tampa Bay
Cnidaria		
Hydrozoa	C	-
Ctenophora	C	-
Nematoda	R	-
Polychaeta (early life stages)	C	C
Gastropoda (early life stages)	C	C
Bivalvia (early life stages)	C	-
Cladocera (unspecified)	C	U
Bosminidae	C	-
Chydoridae		
Alona	C	-
Camptocercus	C	-
Chydorus	C	-
Kurzia	O	-
Leydigia	O	-
Alonella	U	-
Euryalona	U	-
Acroperus	R	-
Dunhevedia	R	-
Daphnidae		
Daphnia	O	-
Simocephalus	O	-
Ceriodaphnia	O	-
Moinadaphnia	O	-
Leptodoridae		
Leptodora	R	-
Macrothricidae		
Ilyocryptus	C	-
Macrothrix	C	-
Grimaldia	R	-
Lathonura	R	-
Polyphemidae		
Evadne	C	-
Podon	O	-
Sididae		
Penilia	C	-
Diaphanosoma	C	-
Sida	O	-
Latonopsis	R	-
Pseudosida	R	-
Ostradoca (unspecified)	C	-
Branchiopoda (early life stage)	R	-
Copepoda (unspecified)	A	A
Calanoida		
Acartia	A	-
Labidocera	C	C
Diaptomus	C	-
Paracalanus	O	-
Pseudodiaptomus	O	-
Temora	O	-
Centropages	U	-
Tortanus	U	-
Eurytemora	R	-
Cyclopoida		
Oithona	A	-
Eucyclops	C	-
Saphirella	C	-
Tropocyclops	C	-
Cyclops	O	-
Macrocyclops	O	-
Ergasilus	O	-
Corycaeus	U	-
Mesocyclops	U	-
Paracyclops	R	-
Halicyclops	R	-
Mylicola	R	-
Caligoida (unspecified)	R	-
Branchiura		
Argulus	O	-
Cirripedia		
Balanus (larvae)	A	A
Mysidacea (early life stages)	U	-
Cumacea (early life stages)	U	-
Isopoda (early life stages)	O	O
Amphipoda (early life stages)	O	O
Decapoda		
Brachyura (early life stages)	A	A
Penaeidae (early life stages)	O	O
Sergestidae (early life stages)	O	A
Anomura (early life stages)	C	C
Porcellanidae (early life stages)	-	A
Brachiopoda (early life stages)	C	-
Chaetoonatha (early life stages)	R	C
Larvacea		
Oikopleura	C	C
Appendicularia	-	C

*Kelly and Dragovich (1967)
Tampa Electric Company (1973)
McNulty, Lindall and Anthony (1974)
Texas Instruments (1977)

A = Abundant
C = Common
O = Occasional occurrences
U = Uncommon
R = Rare
P = Present, but with no indication of abundance

are hydrozoa and ctenophores (comb-jellies). Microzooplankton densities ranged from approximately 1500 organisms per cubic meter to more than 300,000 per cubic meter; greatest densities were in the midharbor reaches rather than in the less saline upper harbor area. Densities of macrozooplankton ranged from 2 to approximately 11,000 per cubic meter. Comparable zooplankton densities (245-7,823 per cubic meter) were reported earlier for Charlotte Harbor (McNulty et al 1974); however, smaller organisms probably were not collected since a 366-micron mesh net was used.

The principal factor influencing composition, distribution, and abundance characteristics of the zooplankton community in Charlotte Harbor is salinity, as indicated by major community shifts (principally in the macrozooplankton) during the period of freshwater intrusion.

b. Macroinvertebrates

The Tampa Bay and Charlotte Harbor estuaries support some of the richest and most diverse macroinvertebrate communities of the U.S. seacoast. Taylor (1973) indicates that the Tampa Bay system contains the greatest diversity and abundance of marine life recorded for any embayment between Chesapeake Bay and the Laguna Madre of Texas. Simon (1974) attributes the presence of this rich biota primarily to the geographic position of the estuary, which lies at the biogeographic boundary between temperate and subtropical waters where winter water temperatures seldom drop low enough to kill tropical organisms and summer water temperatures are moderate enough to be tolerated by many of the temperate species. Also contributing to maintenance of rich and diverse macroinvertebrate communities is the abundant supply of nutrients from high primary productivity of salt marshes and mangroves (Simon 1974).

Macroinvertebrates reported from the Tampa Bay and Charlotte Harbor estuarine study areas and their relative abundances are listed in Table 2.19. Major groups, or kinds, of macroinvertebrates inhabiting the Tampa Bay and Charlotte Harbor estuaries include:

Scientific Name	Common Name
Porifera	Sponges
Cnidaria (Coelenterata)	Hydroids, Medusae (jellyfishes)
Ctenophora	Comb-jellies, Ctenophores
Platyhelminthes	Flatworms
Nemertea (Rhynchocoeta)	Nemertean (or ribbon) worms
Chaetognatha	Arrow worms
Polychaeta	Bristleworms, Polychaetes
Bryozoa	Moss animals
Gastropoda	Snails and slugs
Bivalvia	Bivalve mollusks (clams, oysters)
Cephalopoda	Squids, octopuses
Sipuncula	Sipunculan (or peanut) worms
Merostomata	Horseshoe crabs
Cladocera	Water fleas
Ostracoda	Ostracods
Copepoda	Copepods
Cirripedia	Barnacles
Stomatopoda	Mantis shrimp
Cumacea	Cumacean shrimp
Tanaidacea	Tanaids
Isopoda	Isopods
Amphipoda	Scuds, beach fleas
Mysidacea	Mysid shrimp
Penaeidea	Penaeid shrimp
Caridea	Caridean shrimp
Anomura	Mud shrimp
Brachyura	True crabs
Brachiopoda	Brachiopods, lamp shells
Holothuroidea	Sea cucumbers
Echinoidea	Sea urchins, sand dollars
Stelleroidea	Starfish, brittle stars
Ascidiacea	Tunicates, sea squirts
Larvacea	Apendicularians
Cephalochordata*	Lancelets

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*Actually a prochordate rather than an invertebrate but included here for purposes of discussion.

Table 2.19. Macroinvertebrate Distribution and Relative Abundance in Charlotte Harbor and Tampa Bay

Taxon	Charlotte Harbor	Tampa Bay
Porifera		
Halichonidae	O	-
Tetillidae	O	-
Clionidae		R
Cnidaria		
Hydrozoa		
Hydra	R	-
Bougainvillia	R	-
Podocoryne	R	-
Anthozoa (unspecified)	C	-
Ctenophora (unspecified)	C	C
Rhynchocoela		
Heteronemertea		
Cerebratulus	O	-
Hoplonemertea		
Oerstedia	C	-
Nematoda (unspecified)	R	-
Chaetognatha		
Sagitta	C	C
Phoronida		
Phoronis	-	C
Brachiopoda		
Glottidia	A	O
Mollusca		
Amphineura		
Tonicella	R	-
Ischnochiton	-	U
Chaetopleura	-	P
Gastropoda		
Nassarius	A	A
Puperita	A	-
Mitrella	C	O
Anachis	C	O
Vitrinella	C	-
Crepidula	C	O
Atys	C	-
Epitonium	C	U
Polinices	C	O
Prunum	O	C
Batillaria	R	C
Neritina	O	P
Aplysia	O	C
Cerithium	O	C
[illegible]	-	C
Fasciolaria	C	O
Strombus	O	R
Sinum	O	O
Polycera	O	-
Cratena	O	-
Urosalpinx	O	O
Odostomia	O	U
Turbonilla	O	P
Natica	O	U
Busycon	U	O
Acteocina	O	P
Diastoma	O	-
Bittium	U	O
Oliva	U	O
Littorina	O	P
Thais	-	O
Pleuroploca	R	U
Olivella	-	U
[illegible]	U	-
Murex	R	U
[illegible]	U	U
Haminoea	U	U
Berghia	U	-
Melanella	U	P
Mollusca (contd)		
Gastropoda (contd)		
Bulla	U	U
Melampus	U	P
Acteon	P	U
Nerita	U	-
Bursatella	U	U
Terebra	-	U
Vermicularia	-	U
Retusa	-	U
Conus	-	U
Marginella	-	U
Cancellaria	-	R
Mangelia	R	-
Glyphostoma	R	-
Cryoturris	R	-
Triphora	R	P
Ancula	R	-
Cerberilla	R	-
Doris	R	-
Detracia	R	-
Calliostoma	R	P
Amnicola	R	-
Ferrissia	R	-
Physa	R	-
Dolabrifera	R	-
Turritella	-	R
Cochliolepis	-	R
Balcis	-	R
Kurtziella	-	R
Diodora	-	P
Arene	-	P
Turbo	-	P
Rissoina	-	P
Cyclostremiscus	-	P
Caecum	-	P
Meioceras	-	P
Modulus	-	P
Cerithiopsis	-	P
Seila	-	P
Calyptraea	-	P
Columbella	-	P
Bullata	-	P
Persicula	-	P
Pyrgocythara	-	P
Stellatoma	-	P
Cerithidea	P	P
Cylichna	-	P
Scaphopoda		
Dentalium	-	R
Bivalvia		
Crassostrea	C	A
Mulinia	A	C
Tagelus	O	A
Amygdalum	C	C
Mercenaria	O	C
Macrocallista	O	C
Dinocardium	O	C
Anadara	C	O
Atrina	U	C
Arcinella	-	C
[illegible]	R	C
Rangia	C	-
Ensis	O	O
Tellina	O	O
Macoma	O	O
Corbula	O	O
Chione	O	O
Gouldia	O	O

Dragovich and Kelly (1964)
Sykes and Hall (1970)
Taylor et al (1971)
Godcharles (1971)
Collard and D'Asaro (1973)
Godcharles and Jaap (1973)
McNulty et al (1974)
Santos and Simon (1974)
U.S. Army Corps of Engineers (1974)
Florida Department of Natural Resources (1975)
Texas Instruments (1977)

A = Abundant
C = Common
O = Occasional occurrences
U = Uncommon
R = Rare
P = Present, but with no indication of abundance

Table 2.19 (Contd)

Taxon	Charlotte Harbor	Tampa Bay
Mollusca (contd)		
Bivalvia (contd)		
Brachidontes	O	U
Modiolus	O	U
Musculus	O	U
Laevicardium	O	U
Aequipecten	U	O
Anatina	O	U
Abra	O	P
Polymesoda	O	R
Argopecten	R	O
Cyrtopleura	R	O
Spisula	-	O
Trachycardium	U	U
Lucina	U	U
Diplodonta	U	U
Mactra	U	U
Lioberus	U	P
Lyonsia	U	P
Semele	U	P
Cardita	R	U
Mytilus	U	-
Americardia	U	-
Myrtea	U	-
Corbicula	U	-
Ischadium	U	-
Anodontia	-	U
Phacoides	-	U
Congeria	U	-
Martesia	-	U
Barbatia	-	U
Mysella	-	U
Nucula	-	U
Gouldia	-	U
Solen	R	-
Varicorbula	R	-
Periglypta	R	-
Anomia	R	-
Crassinella	R	P
Donax	R	P
Sphaerium	R	-
Echinochama	-	R
Thracia	-	R
Nuculana	-	R
Ostrea	P	P
Geukensia	P	-
Anomalocardia	-	P
Cyclinella	-	P
Parastarte	-	P
Pitar	-	P
Petricola	-	P
Psammotreta	-	P
Tellidora	-	P
Cumingia	-	P
Pandora	-	P
Periploma	-	P
Pecten	-	P
Arca	-	P
Barnea	-	P
Bankia	-	P
Crenella	-	P
[illegible]	-	P
Montacuta	-	P
Plicatula	-	P
Solemya	-	P
Teredo	-	P
Venericardia	-	P
Cephalopoda		
Lolliguncula	O	A
Illex	U	P
Octopus	-	U
Loligo	-	P
Annelida		
Polychaeta		
Streblospio	A	A
Nereis	A	A
Polydora	C	A
Onuphis	U	A
Travisia	R	A
Annelida (contd)		
Polychaeta (contd)		
Lumbrineris	R	A
Prionospio	R	A
Branchioma	R	A
Fabricia	-	A
Capitella	-	A
Minuspio	-	A
Magelona	-	A
Apoprionospio	-	A
Capitita	-	A
Paraprionospio	-	A
Spiochaetopterus	-	A
Eteone	C	C
Phyllodoce	C	C
Glycera	C	C
Pectinaria	C	O
Diopatra	R	C
Scoloplos	R	C
Chaetopterus	C	U
Heteromastus	-	C
Gyptis	-	C
Brania	-	C
Glycinde	-	C
Aricidea	-	C
Pseudopolydora	-	C
Clymenella	-	C
Scolelepis	-	C
Laeonereis	-	C
Melinna	O	O
Nephtys	O	U
Harmothoe	O	P
Tharyx	R	O
Parahesione	O	P
Arenicola	R	O
Eumida	-	O
Drilonereis	-	O
Paraonis	-	O
Capitellides	-	O
Arabella	-	O
Lepidonotus	U	U
Lepidametria	U	P
Maldane	U	U
Cirriformia	U	P
Chone	U	P
Armandia	U	P
Pherusa	U	P
[illegible]	U	-
Cirratulus	U	-
Goniada	U	-
Euchone	U	-
Cistenides	U	-
Phyllohartmania	-	U
Owenia	-	U
Branchioasychis	-	U
Sthenelais	R	P
Sabella	R	P
Autolytus	R	P
Ammotrypane	R	P
Axiothella	R	-
Amphicteis	R	-
[illegible]	-	P
Euphrosine	-	P
Aglaophamus	-	P
Amphitrite	-	P
Ancistrosyllis	-	P
Aonides	-	P
Asabellides	-	P
Boguea	-	P
Branchiosyllis	-	P
Cabira	-	P
Capitomastus	-	P
Caulleriella	-	P
Ceratonereis	-	P
Dasybranchus	-	P
[illegible]	-	P
Exogone	-	P
Goniadella	-	P
Haploscoloplos	-	P

Table 2.19 (Contd)

Taxon	Charlotte Harbor	Tampa Bay
Annelida (contd)		
Polychaeta (contd)		
Hesione	-	P
Hydroides	-	P
Isolda	-	P
Loimia	-	P
Lumbrineris	-	P
Lysarete	-	P
Marphysa	-	P
Megalomma	-	P
Myriochele	-	P
Naineris	-	P
Namalycastis	-	P
Nematonereis	-	P
Nereiphylla	-	P
Notomastus	-	P
Odontosyllis	-	P
Ophryotrocha	-	P
Orbinia	-	P
Paleanotus	-	P
Paranaites	-	P
Perinereis	-	P
Petaloproctus	-	P
Pholoe	-	P
Pilargis	-	P
Pionosyllis	-	P
Pisione	-	P
Pista	-	P
Platynereis	-	P
Podarke	-	P
Poecilochaetus	-	P
Polycirrus	-	P
Polyodontes	-	P
Pseudeurythoe	-	P
Rullierinereis	-	P
Sabellaria	-	P
Salmacina	-	P
Scyphoproctus	-	P
Sigalion	-	P
Sigambra	-	P
Sphaerosyllis	-	P
Spio	-	P
Spiophanes	-	P
Spirorbis	-	P
Stauronereis	-	P
Syllis	-	P
Terebella	-	P
Thelepus	-	P
Trichobranchus	-	P
Trochochaeta	-	P
Oligochaeta		
Naididae	U	-
Tubificidae	O	-
Hirundinea		
Branchellion	U	-
Glossiphonia	R	-
Sipunculida (unspecified)	U	O
Siphonosoma	U	R
Siphonomecus	U	-
Sipunculus	R	-
Arthropoda		
Merostomata		
Limulus	C	O
Insecta-Diptera		
Culicidae	C	C
Chironomidae	O	-
Phoridae	U	-
Muscidae	U	-
Ostracoda	O	-
Cladocera		
[illegible]	U	-
Penilia	O	-
Evadne	O	-
Cirripedia		
Balanus	C	C
Stomatopoda		
Squilla	-	C
Cumacea (unspecified)	O	R
Cyclaspis	C	-
Oxyurostylis	C	-
Diastylis	U	-
Leucon	U	-
Tanaidacea		
Leptochelia	C	-
Isopoda		
Erichsonella	C	-
Aegathoa	O	C
Sphaeroma	O	C
Cyathura	C	-
Exosphaeroma	O	-
Probopyrus	U	-
Chiridotea	R	-
Ligyda	R	-
Apanthura	P	-
Amphipoda		
Erichthonius	A	-
Acanthohaustorius	-	A
Gammarus	C	-
Batea	C	-
Microdeutopus	C	-
Ampelisca	C	-
Aeginella	-	-
Corophium	C	-
Melita	O	-
Ampithoe	O	-
Caprella	O	-
[illegible]	U	-
Carinobatea	U	-
Leucothoe	U	-
[illegible]	U	-
Grandidierella	U	-
Cymadusa	U	-
[illegible]	R	-
[illegible]	R	-
Mysidacea		
Mysidopsis	C	-
Bowmaniella	O	-
Taphromysis	R	-

Table 2.19 (Contd)

Taxon	Charlotte Harbor	Tampa Bay
Decapoda		
Penaeus	C	A
Callinectes	C	A
Tozeuma	C	A
Lucifer	O	A
Neopanope	C	C
Libinia	C	C
Alpheus	C	C
Palaemonetes	C	C
Periclimenes	C	C
Pagurus	C	C
Pinnixa	C	O
Hippolyte	C	O
Latreutes	C	O
Hippolysmata	O	C
Callianassa	O	C
Leander	C	U
Penaeopsis	C	-
Rhithropanopeus	C	-
Synalpheus	-	C
Upobegia	-	C
Menippe	O	O
Pitho	O	O
Portunus	O	O
Panopeus	U	O
Persephona	O	U
Hepatus	U	O
Uca	O	U
Hexapanopeus	O	R
Petrolisthes	R	O
Trachypeneus	-	O
Sicyonia	-	O
Metoporhaphis	-	O
Polyonyx	O	-
Ogyrides	O	-
Processa	O	-
Macrobrachium	O	-
Pontonia	U	R
Pachygrapsus	U	-
Podochela	-	U
Pinnotheres	-	U
Parapenaeus	U	-
Emerita	-	U
Eurypanopeus	R	R
Heterocrypta	-	R
Pinnotheres	R	-
Sesarma	R	-
Calappa	-	R
Hypoconcha	-	R

Taxon	Charlotte Harbor	Tampa Bay
Arthropoda (contd)		
Decapoda (contd)		
Ovalipes	-	R
Pilumnus	-	R
Leptochela	R	
Albunea	-	R
[illegible]	R	-
Petrochirus	-	R
Aratus	P	-
Leptalpheus	-	P
Echinodermata		
Holothuroidea		
Leptosynapta	O	O
Thyone	O	O
Pentacta	-	O
Thyonella	-	U
Theelothuria	-	R
Pentamera	-	P
Sclerodactyla	-	P
Echinoidea		
Mellita	A	A
Moira	C	O
Lytechinus	O	O
Encope	R	O
Arbacia	R	U
Stelleroidea		
Luidia	C	C
Ophioderma	O	O
Echinaster	O	O
Ophiophragmus	O	O
Astropecten	R	O
Micropholis	-	O
Ophionema	O	-
Ophiolepis	R	U
Ophiothrix	-	U
Ophiactis	-	P
Hemipholis	-	P
Amphioplus	-	P
Hemichordata		
Saccoglossus	R	-
Urochordata		
Ascidiacea		
Molgula	C	A
Styela	U	U
Larvacea		
Oikopleura	C	C
Appendicularia	-	C
Cephalochordata		
Branchiostoma	C	C

There are numerous forms of commercially or recreationally valuable macroinvertebrates within the two estuaries, e.g., pink shrimp, stone crab, blue crab, oyster, bay scallop, southern quahog, sunray venus clam, and squid and, to a lesser extent, pen shell, surf clam, marsh clam, coquina, whelk, lugworm, and sand dollar. By far, the most valuable is the pink shrimp. These commercially and recreationally important species of Tampa Bay and Charlotte Harbor are discussed in more detail in Section 3.

The estuarine macroinvertebrate fauna may be conveniently divided into a water-column assemblage and a benthic assemblage. A third assemblage, but one of lesser diversity, is organisms that live attached to hard substrates in the water column (e.g., oysters and barnacles). Although some organisms are known to migrate regularly from the benthic substrate into the water column, any form regularly collected in the water column is considered a water-column inhabitant for this discussion.

Benthic macroinvertebrates having life stages that are planktonic (and generally microscopic) in the water column were included as zooplankton (meroplankton) in the previous subsection.

Macroinvertebrates that may be regarded as major water column inhabitants of the Tampa Bay estuaries include ctenophores, the penaeid shrimp *Lucifer faxoni*, caridean shrimp *Palaemonetes*, *Periclimines*, *Alpheus*, *Synalpheus*, *Tozeuma*, *Hippolysmata*, and *Latreutes*, the isopod *Aegathoa*, appendiculariids (principally *Appendicularia* and *Oikopleura*), the squid *Lolliguncula brevis*, and the chaetognath *Sagitta* (Kelly and Dragovitch 1967, Lindall et al 1973). Macroinvertebrates common in the Charlotte Harbor water column include ctenophores, Hydrozoa, *Aegathoa*, *Lucifer*, *Oikopleura*, and *Sagitta* (TI 1977).

Recently, 86 locations throughout the Tampa Bay estuary yielded more than 300 species of 17 major groups of benthic invertebrates (U.S. Army Corps of Engineers 1974). Annelid worms (principally polychaetes) comprised more than half of all animals collected, dominating the benthic assemblage of every location. Arthropods (mostly isopods, amphipods, and cumaceans) were the next most common group, followed by mollusks, chordates (primarily lancelets), and echinoderms (primarily brittle stars). All groups were more abundant in the middle reaches of the estuary than offshore or in central Hillsborough Bay. Upper Hillsborough Bay had low densities as well as the lowest benthic community diversity — an indication of degraded water quality. Abundances varied between locations having soft substrates and those with firm substrates: greatest numbers occurred in substrates comprised of 20 percent or more silt and clay. Predominant mollusks in the soft bottoms represent the genera *Corbula*, *Tellina*, *Mulinia*, and *Macoma*; dominant polychaetes in soft bottoms are spionids. Apparently, neither substrate consistency nor salinity (relatively high versus low) completely controls the local abundance of benthic macroinvertebrates in the estuary.

Recently in the Charlotte Harbor estuary, there were slightly more than 300 taxa of benthic macroinvertebrates (TI 1977). In terms of contributions to the community's diverse assemblage, the major components are the decapods (60 taxa), snails (53 taxa), polychaetes (50 taxa), and bivalves (47 taxa). Most common are the polychaetes *Streblospio*, *Pectinaria gouldi*, and *Nereis*; the gastropod *Mitrella lunata*; the bivalve *Mulinia lateralis*; the amphipod *Ampelisca*; the long-armed hermit crab *Pagurus longicarpus*; and the brachiopod *Glottidia pyramidata*. As in Tampa Bay, several species of clams were confined to a soft (muck/detritus) substrate.

Charlotte Harbor's infauna community is more diverse and complex than that of the Tampa Bay study area. In general, polychaetes and amphipods dominate this community; the exception occurs in May when the cumacean *Cyclapsis* also is dominant. Prevalent forms in the epifauna community include the amphipods *Erichthonius* and *Ampelisca*; the gastropods *Nassarius vibex*, *Atys caribea*, and *Mitrella lunata*; and the bivalves *Mulinia lateralis* and *Amygdalum papyria* (TI 1977). One distinction between macroinvertebrate communities of Tampa Bay and Charlotte Harbor is related to the effects of the rainy season and surface runoff. As Simon (1974) has indicated, there are no wide fluctuations in the salinity regime of the Tampa Bay estuary, thus allowing many marine species to coexist with truly estuarine forms. This is clearly not the case in Charlotte Harbor where considerable salinity dilution occurs during the Peace River's high discharge period, essentially limiting numerical dominance to truly euryhaline forms, especially in the upper harbor area.

Table 2.20. Estuarine/Marine Fishes of Study Area

Common Name	Scientific Name	Special Status
Sand tiger	*Odontaspis taurus*	
White shark	*Carcharodon carcharias*	
Nurse shark	*Ginglymostoma cirratum*	
Finetooth shark	*Aprionodon isodon*	
Blacknose shark	*Carcharhinus acronotus*	
Silky shark	*Carcharhinus falciformis*	
Bull shark	*Carcharhinus leucas*	
Blacktie shark	*Carcharhinus limbatus*	
Spinner shark	*Carcharhinus maculipinnis*	
Sandbar shark	*Carcharhinus milberti*	
Dusky shark	*Carcharhinus obscurus*	
Tiger shark	*Galeocerdo cuvieri*	
Florida smoothhound	*Mustelus norrisi*	
Lemon shark	*Negaprion brevirostris*	
Atlantic sharpnose shark	*Rhizoprionodon terraenovae*	
Scalloped hammerhead	*Sphyrna lewini*	
Great hammerhead	*Sphyrna mokarran*	
Bonnethead	*Sphyrna tiburo*	
Smalltooth sawfish	*Pristis pectinata*	
Atlantic guitarfish	*Rhinobatos lentiginosus*	
Clearnose skate	*Raja eglanteria*	
Southern stingray	*Dasyatis americana*	
Roughtail stingray	*Dasyatis centroura*	
Atlantic stingray	*Dasyatis sabina*	
Smooth butterfly ray	*Gymnura micrura*	
Bluntnose stingray	*Dasyatis sayi*	
Spotted eagle ray	*Aetobatus narinari*	
Cownose ray	*Rhinoptera bonasus*	Commercial
Atlantic manta	*Manta birostris*	
Atlantic sturgeon	*Acipenser oxyrhynchus*	Threatened (FCREPA)
Ladvfish	*Elops saurus*	Sport; commercial
Tarpon	*Megalops atlantica*	Sport
Bonefish	*Albula vulpes*	Sport
Blackedge moray	*Gymnothorax nigromarginatus*	
	Gymnothorax saxicola	
Conger eel	*Conger oceanicus*	
Spotted snake eel	*Ophichthus ophis*	
Snapper eel	*Mystriophis mordax*	
Sailfin eel	*Letharchus velifer*	
Specked worm eel	*Myrophis punctatus*	
Stippled spoon-nose eel	*Mystriophis punctifer*	
Shrimp eel	*Ophichthus gomesi*	
Whip eel	*Bascanichthys scuticaris*	
Spotted spoon-nose eel	*Mystriophis intertinctus*	
Sooty eel	*Bascanichthys teres*	
Finescale menhaden	*Brevoortia gunteri*	Commercially important
Gulf menhaden	*Brevoortia patronus*	Commercially important
Yellowfin menhaden	*Brevoortia smithi*	Commercially important
Atlantic menhaden	*Brevoortia tyrannus*	
Round herring	*Etrumeus teres*	
Scaled sardine	*Harengula pensacolae*	Important forage for commercial species; commercial
Atlantic thread herring	*Opisthonema oglinum*	Important forage for commercial species; commercially importan
Spanish sardine	*Sardinella anchovia*	
Orangespot sardine	*Sardinella brasiliensis*	
Threadfin shad	*Dorosoma petenense*	
Cuban anchovy	*Anchoa cubana*	
Striped anchovy	*Anchoa hepsetus*	
Bay anchovy	*Anchoa mitchilli*	
Inshore lizardfish	*Synodus foetens*	Commercial
Sand diver	*Synodus intermedius*	
Sea catfish	*Arius felis*	Commercial
Gafftopsail catfish	*Bagre marinus*	
Gulf toadfish	*Opsanus beta*	Commercial
Oyster toadfish	*Opsanus tau*	
Atlantic midshipman	*Porichthys porosissimus*	
Leopard toadfish	*Opsanus pardus*	
Skilletfish	*Gobiesox strumosus*	
Ocellated frogfish	*Antennarius ocellatus*	
Sargassumfish	*Histrio histrio*	
Shortnose batfish	*Ogcocephalus nasutus*	Commercial
Batfish sp.	*Ogcocephalus rubifrons*	
Polka-dot batfish	*Ogcocephalus radiatus*	Commercial
Pancake batfish	*Halieutichthys aculeatus*	
Southern hake	*Urophycis floridanus*	Commercial
Bank cusk-eel	*Ophidion holbrooki*	
Crested cusk-eel	*Ophidion welshi*	
Longnose cusk-eel	*Ophidion beani*	
Blotched cusk-eel	*Ophidion grayi*	
Atlantic flyingfish	*Cypselurus heterurus*	
Flyingfish	*Cypselurus lutkeni*	
Bluntnose flyingfish	*Prognichthys gibbifrons*	
Halfbeak	*Hyporhamphus unifasciatus*	Commercial
Ballyhoo	*Hemiramphus brasiliensis*	

Table 2.20 (Contd)

Common Name	Scientific Name	Special Status
Flat needlefish	*Ablennes hians*	
Atlantic needlefish	*Strongylura marina*	
Redfin needlefish	*Strongylura notata*	
Timucu	*Strongylura timucu*	
Houndfish	*Tylosurus crocodilus*	
Diamond killifish	*Adinia xenica*	
Marsh killifish	*Fundulus confluentus*	
Gulf killifish	*Fundulus grandis*	
Longnose killifish	*Fundulus similis*	
Rivulus	*Rivulus marmoratus*	Threatened (FCREPA)
Rough silverside	*Membras martinica*	
Tidewater silverside	*Menidia beryllina*	Important forage for commercial species; commercial
Deepbody boarfish	*Antigonia capros*	
arfish	[illegible]	
Bluespotted cornetfish	*Fistularia tabacaria*	
Dwarf seahorse	*Hippocampus zosterae*	
Fringed pipefish	*Micrognathus crinigerus*	
Shortfin pipefish	*Syngnathus elucens*	
Dusky pipefish	*Syngnathus floridae*	
Chain pipefish	*Syngnathus louisianae*	
Gulf pipefish	*Syngnathus scovelli*	Commercial
Bull pipefish	*Syngnathus springeri*	
Opossum pipefish	*Oostethus lineatus*	Rare (FCREPA)
Lined seahorse	*Hippocampus erectus*	Commercial
Fat snook	*Centropomus parallelus*	
Tarpon snook	*Centropomus pectinatus*	
Snook	*Centropomus undecimalis*	Game
Southern sea bass	*Centropristis melana*	Commercial
Bank sea bass	*Centropristis ocyurus*	
Rock sea bass	*Centropristis philadelphica*	
Sand perch	*Diplectrum formosum*	Commercial
Speckled hind	*Epinephelus drummondhayi*	Sport
Jewfish	*Epinephelus itajara*	Sport
Rock hind	*Epinephelus adscensionis*	Sport; commercial
Red grouper	*Epinephelus morio*	Sport; commercially important
Red hind	*Epinephelus guttatus*	Sport
Gag (black grouper)	*Mycteroperca microlepis*	Sport; commercially important
Scamp	*Mycteroperca phenax*	Commercially important
Yellowfin grouper	*Mycteroperca venenosa*	Sport
Belted sandfish	*Serranus subligarius*	
Pygmy sea bass	*Serraniculus pumilio*	
Black sea bass	*Centropristis striata*	Sport
Freckled soapfish	*Rypticus bistrispinus*	
Greater soapfish	*Rypticus saponaceus*	
Cobia	*Rachycentron canadum*	Sport
Freckled cardinalfish	*Phaeoptyx conklini*	
Flamefish	*Apogon maculatus*	
Bronze cardinalfish	*Astrapogon alutus*	
Bluefish	*Pomatomus saltatrix*	Sport; commercially important
Sharksucker	*Echeneis naucrates*	Commercial
Remora	*Remora remora*	
Blue runner	*Caranx crysos*	Sport; commercial
Crevalle jack	*Caranx hippos*	Sport; commercially important
Horse-eye jack	*Caranx latus*	
Rough scad	*Trachurus lathami*	
Atlantic bumper	*Chloroscombrus chrysurus*	Commercial
Leatherjacket	*Oligoplites saurus*	Commercial
Lookdown	*Selene vomer*	
Greater amberjack	*Seriola dumerili*	Sport
Banded rudderfish	*Seriola zonata*	
Florida pompano	*Trachinotus carolinus*	Sport; commercially important
Bluntnose jack	*Hemicaranx amblyrhynchus*	Sport; commercially important
Permit	*Trachinotus falcatus*	
Palometa	*Trachinotus goodei*	
Atlantic moonfish	*Vomer setapinnis*	
Dolphin	*Coryphaena hippurus*	Sport
Gray (mangrove) snapper	*Lutjanus griseus*	Sport; commercially important
Lane snapper	*Lutjanus synagris*	Sport; commercial
Yellowtail snapper	*Ocyurus chrysurus*	Sport; commercial
Vermilion snapper	*Rhomboplites aurorubens*	Commercially important
Tripletail	*Lobotes surinamensis*	Sport
Irish pompano	*Diapterus olisthostomus*	
Striped mojarra	*Diapterus plumieri*	Commercially important
Spotfin mojarra	*Eucinostomus argenteus*	Commercially important
Silver jenny	*Eucinostomus gula*	Commercially important
White grunt	*Haemulon plumieri*	Sport; commercial
Pigfish	*Orthopristis chrysoptera*	Commercial
French grunt	*Haemulon flavolineatum*	
Bluestriped grunt	*Haemulon sciurus*	Sport
Tomtate	*Haemulon aurolineatum*	
Sheepshead	*Archosargus probatocephalus*	Sport
Grass porgy	*Calamus arctifrons*	Commercial
Spottail pinfish	*Diplodus holbrooki*	
Pinfish	*Lagodon rhomboides*	Important forage for commercial species; commercial
Red porgy	*Pagrus sedecim*	
Littlehead porgy	*Calamus proridens*	

Table 2.20 (Contd)

Common Name	Scientific Name	Special Status
High-hat	*Equetus acuminatus*	
Spotted seatrout	*Cynoscion nebulosus*	Sport; commercially important
Sand seatrout	*Cynoscion arenarius*	Commercially important
Spot	*Leiostomus xanthurus*	Commercially important
Silver perch	*Bairdiella chrysura*	Important forage for commercial species; commercial
Weakfish	*Cynoscion regalis*	
Southern kingfish	*Menticirrhus americanus*	Commercial
Minkfish	*Menticirrhus focaliger*	
Atlantic croaker	*Micropogon undulatus*	Commercially important
Red drum	*Sciaenops ocellata*	Sport; commercially important
Black drum	*Pogonias cromis*	Sport; commercially important
Jacknife-fish	*Equetus lanceolatus*	
Cubbyu	*Equetus umbrosus*	
Gulf kingfish	*Menticirrhus littoralis*	
Red goalfish	*Mullus auratus*	
Spotted goalfish	*Pseudupeneus maculatus*	
Bermuda chub	*Kyphosus sectatrix*	
Atlantic spadefish	*Chaetodipterus faber*	Sport; commercial
Slippery dick	*Halichoeres bivittatus*	
Pearly razorfish	*Hemipteronotus novacula*	
Emerald parrotfish	*Nicholsina usta*	
Striped mullet	*Mugil cephalus*	Commercially important
White mullet	*Mugil curema*	Commercially important
Fantail mullet	*Mugil trichodon*	Commercially important
Mountain mullet	*Agonostomus monticola*	Rare (FCREPA)
Great barracuda	*Sphyraena barracuda*	Sport
Northern sennet	*Sphyraena borealis*	
Southern sennet	*Sphyraena picudilla*	Commercial
Atlantic threadfin	*Polydactylus octonemus*	
Spotfin jawfish	*Opistognathus macrognathus*	
Mottled jawfish	*Opistognathus maxillosus*	
Sand stargazer	*Dactyloscopus tridigitatus*	
Southern stargazer	*Astroscopus y-graecum*	
Marbled blenny	*Paraclinus marmoratus*	
Banner blenny	*Emblemaria atlantica*	
Banded blenny	*Paraclinus fasciatus*	
Florida blenny	*Chasmodes saburrae*	
Seaweed blenny	*Blennius marmoreus*	
Crested blenny	*Hypleurochilus geminatus*	
Feather blenny	*Hypsoblennius hentzi*	Commercial
Highfin blenny	*Blennius nicholsi*	
Spotfin dragonet	*Callionymus agassizi*	
Spotted dragonet	*Callionymus pauciradiatus*	
Seminole goby	*Microgobius carri*	
Emerald goby	*Gobionellus smaragdus*	
Highfin goby	*Gobionellus oceanicus*	
Clown goby	*Microgobius gulosus*	
Darter goby	*Gobionellus boleosoma*	
Frillfin goby	*Bathygobius soporator*	
Naked goby	*Gobiosoma bosci*	
Code goby	*Gobiosoma robustum*	
Crested goby	*Lophogobius cyprinoides*	
Green goby	*Microgobius thalassinus*	
Spotted goby	*Coryphopterus punctipectophorus*	
Twoscale goby	*Gobiosoma longipala*	
Tiger goby	*Gobiosoma macrodon*	
Blue goby	*Ioglossus calliurus*	
Sharptail goby	*Gobionellus hastatus*	
Pink warmfish	*Microdesmus longipinnis*	
Atlantic cutlassfish	*Trichiurus lepturus*	
Wahoo	*Acanthocybium solanderi*	
Blackfin tuna	*Thunnus atlanticus*	Sport
Spanish mackerel	*Scomberomorus maculatus*	Sport; commercially important
Chub mackerel	*Scomber japonicus*	
King mackerel	*Scomberomorus cavalla*	Sport; commercially important
Harvestfish	*Peprilus alepidotus*	
Butterfish	*Peprilus triacanthus*	
Barbfish	*Scorpaena brasiliensis*	Commercial
Smoothhead scorpionfish	*Scorpaena calcarata*	
Spotted scorpionfian	*Scorpaena plumieri*	
Leopard searobin	*Prionotus scitulus*	Commercial
Bighead searobin	*Prionotus tribulus*	Commercial
Bandtail searobin	*Prionotus ophryas*	
Blackfin searobin	*Prionotus rubio*	
Bluespotted searobin	*Prionotus roseus*	

Table 2.20 (Contd)

Common Name	Scientific Name	Special Status
Ocellated flounder	*Ancylopsetta quadrocellata*	Commercial
Spotted whif	*Citharichthys macrops*	
Fringed flounder	*Etropus crossotus*	Commercial
Gulf flounder	*Paralichthys albigutta*	Sport; commercial
Dusky flounder	*Syacium papillosum*	
Spotfin flounder	*Cyclopsetta fimbriata*	
Eyed flounder	*Bothus ocellatus* *Bothus robinsi*	
Fourspot flounder	*Paralichthys oblongus*	Sport; commercial
Hogchoker	*Trinectes maculatus*	Commercial
Lined sole	*Achirus lineatus*	Commercial
Naked sole	*Gymnachirus melas*	
Blackcheek torguefish	*Symphurus plagiusa*	Commercial
Jambeau	*Parahollardia lineata*	
Gray triggerfish	*Balistes capriscus*	Sport; commercial
Fringed filefish	*Monacanthus ciliatus*	
Orange filefish	*Aluterus schoepfi*	Commercial
Planehead filefish	*Monacanthus hispidus*	
Scrawled cowfish	*Lactophrys quadricornis*	Commercial
Smooth trunkfish	*Lactophrys triqueter*	
Trunkfish	*Lactophrys trigonus*	
Smooth puffer	*Lagocephalus laevigatus*	
Marbled puffer	*Sphoeroides dorsalis*	
Northern puffer	*Sphoeroides maculatus*	Commercial
Southern puffer	*Sphoeroides nephelus*	Commercial
Bandtail puffer	*Sphoeroides spengleri*	
Striped burrfish	*Chilomycterus schoepfi*	Commercial
Balloonfish	*Diodon holocanthus*	
Porcupinefish	*Diodon hystrix*	

Table 2.21. Fish Distribution and Abundance in Estuarine Habitats

	Charlotte Harbor	Coastal Zone Between	Tampa Bay
Sand tiger	P	-	R
White shark	-	P	
Nurse shark	P	-	C
Finetooth shark	P	-	-
Blacknose shark	A	A	R
Silky shark	-	-	R
Bull shark	C	A	C
Blacktip shark	O	C	C
Spinner shark	P	C	-
Sandbar shark	P	A	U
Dusky shark	P	C	-
Tiger shark	P	-	-
Florida smoothhound	P	R	O
Lemon shark	P	A	C
Atlantic sharpnose shark	-	C	-
Scalloped hammerhead	P	R	R
Great hammerhead	P	P	R
Bonnethead	R	C	O
Smalltooth sawfish	R	P	R
Atlantic guitarfish	C	C	R
Clearnose skate	P	C	-
Southern stingray	R	C	-
Roughtail stingray	-	P	-
Atlantic stingray	O	C	O
Smooth butterfly ray	O	C	R
Bluntnose stingray	R	-	-
Spotted eagle ray	R	C	C
Cownose ray	C	C	O
Atlantic manta	P	P	C
Atlantic sturgeon	-	-	R
Longnose gar	O	-	R
Florida gar	A	C	-
Ladyfish	O	P	O
Tarpon	R	P	O
Bonefish	-	P	-
American eel	R	-	O
Blackedge moray	P	P	R
Conger eel	-	-	R
Spotted snake eel	R	-	-
Snapper eel	-	R	-
Sailfin eel	-	-	R
Speckled worm eel	R	C	A
Stippled spoon-nose eel	-	-	R
Shrimp eel	R	C	R
Whip eel	P	R	-
Spotted spoon-nose eel	P	P	R
Sooty eel	-	-	O
Finescale menhaden	-	-	O
Gulf menhaden	R	C	A
Yellowfin menhaden	O	P	O
Atlantic menhaden	R	-	-
Gizzard shad	-	-	R
Threadfin shad	O	C	C
Round herring	-	P	-
Scaled sardine	O	A	C
Atlantic thread herring	U	A	C
Spanish sardine	R	A	A
Orangespot sardine	-	C	R
Cuban anchovy	O	P	C
Striped anchovy	C	A	O
Bay anchovy	A	A	A
Inshore lizardfish	U	A	O
Sand diver	R	-	-
Golden shiner	P	P	-
Coastal shiner	R	-	-
Dusky shiner	R	-	-
Yellow bullhead	R	-	-
White catfish	U	-	-
Channel catfish	R	-	R
Brown bullhead	-	-	R
Sea catfish	C	A	C
Gafftopsail catfish	C	C	O
Gulf toadfish	U	C	U
Oyster toadfish	P	C	-
Atlantic midshipman	-	R	P
Leopard toadfish	-	P	P
Skilletfish	A	P	O
Ocellated frogfish	P		R
Sargassumfish	P	C	R
Shortnose batfish	-	C	-
Polka-dot batfish	P	P	-
Pancake batfish	-	-	P
Southern hake	U	P	-
Bank cusk-eel	P	-	R
Crested cusk-eel	P	P	R
Longnose cusk-eel	-	-	P
Blotched cusk-eel	-	-	-
Atlantic flyingfish	P	P	-
Flyingfish	-	P	P
Bluntnose flyingfish	-	-	P
Halfbeak	R	-	O
Ballyhoo	-	-	R
Flat needlefish	P	P	-
Atlantic needlefish	R	A	R
Redfin needlefish	U	A	-
Timucu	O	C	C
Houndfish	P	C	R
Diamond killifish	R	C	R
Sheepshead minnow	O	A	C
Goldspotted killifish	C	A	O
Golden topminnow	P	P	-
Marsh killifish	O	P	-
Gulf killifish	C	A	O
Longnose killifish	-	A	O
Flagfish	P	-	-
Rainwater killifish	C	C	A
Seminole killifish	O	-	-
Rivulus	-	-	R
Bluefin killifish	R	-	-
Mosquitofish	A	P	R
Sailfin molly	O	C	C
Rough silverside	O	A	R
Tidewater silverside	A	A	A
Deepbody boarfish	-	P	-
Dartfish	P	R	R
Bluespotted cornetfish	-	P	-
Dwarf seahorse	R	C	A
Fringed pipefish	R	C	R
Shortfin pipefish	-	P	-
Dusky pipefish	C	A	O
Chain pipefish	U	A	O
Gulf pipefish	O	A	O
Bull pipefish	R	P	-
Opossum pipefish	-	-	R
Lined seahorse	O	A	O
Fat snook	P	P	-
Tarpon snook	P	P	-
Snook	C	C	C
Southern sea bass	O	C	R
Bank sea bass	P	P	R
Rock sea bass	-	P	-
Sand perch	O	C	C
Speckled hind	P	R	R
Jewfish	R	O	O
Rock hind	R	O	R
Red grouper	R	P	P
Red hind	-	P	-
Gag	U	C	C
Scamp	P	-	-
Yellowfin grouper	-	-	-
Belted sandfish	O	A	O

Springer and Woodburn (1960)
Springer and McErlean (1961)
Moe (1963)
Sykes and Finucane (1966)
Gunter (1967)
Mote Marine Laboratory (1968)
Wang and Raney (1971)
Powell et al (1972)
McNulty et al (1974)
U.S. Corps of Engineers (1974)
Florida Department of Natural Resources (1975)
Texas Instruments (1977)

A = Abundant
C = Common
O = Occasional occurrences
U = Uncommon
R = Rare
P = Present, but with no indication of abundance

Table 2.21 (Contd)

	Charlotte Harbor	Coastal Zone Between	Tampa Bay
Pygmy sea bass	-	-	-
Black sea bass	P	-	-
Freckled soapfish	-	-	-
Greater soapfish	P	-	P
Cobia	-	C	R
Bluegill	P	-	-
Redear sunfish	R	-	-
Everglades pygmy sunfish	-	-	-
Bluespotted sunfish	P	-	-
Largemouth bass	-	-	-
Freckled cardinalfish	P	-	-
Flamefish	P	-	-
Bronze cardinalfish	-	-	-
Bluefish	R	C	C
Sharksucker	U	C	O
Remora	-	P	-
Blue runner	P	C	C
Crevalle jack	O	A	A
Horse-eye jack	P	C	R
Rough scad	-	C	R
Atlantic bumper	O	C	R
Leatherjacket	O	A	A
Lookdown	R	C	U
Greater amberjack	P	P	-
Banded rudderfish	P	P	R
Florida pompano	P	O	A
Bluntnose jack	R	-	-
Permit	O	A	C
Palometa	P	P	-
Atlantic moonfish	R	-	R
Dolphin	-	O	-
Gray snapper	U	P	O
Lane snapper	O	P	O
Yellowtail snapper	-	P	P
Vermilion snapper	P	C	P
Red snapper	-	-	-
Tripletail	R	P	R
Irish pompano	-	-	P
Striped mojarra	C	C	A
Spotfin mojarra	C	C	O
Silver jenny	C	C	A
White grunt	R	A	A
Pigfish	O	C	O
French grunt	-	-	R
Bluestriped grunt	-	-	P
Tomtate	R	-	R
Sheepshead	O	A	O
Grass porgy	R	O	U
Spottail pinfish	U	C	U
Pinfish	A	A	A
Red porgy	R	-	-
Littlehead porgy	-	-	P
High-hat	P	C	-
Spotted seatrout	O	A	O
Sand seatrout	A	C	O
Spot	C	A	A
Silver perch	C	A	A
Weakfish	U	P	-
Southern kingfish	O	C	O
Minkfish	U	C	O
Atlantic croaker	O	R	U
Red drum	O	C	O
Black drum	O	P	C
Jackknife-fish	-	P	-
Cubbyu	-	-	P
Gulf kingfish	R	A	-
Red goatfish	R	P	-
Spotted goatfish	-	P	P
Bermuda chub	P	P	R
Atlantic spadefish	O	P	U
Blackchin mouthbrooder	-	-	A
[illegible]	-	-	A
Blue tilapia	O	-	-
Slippery dick	O	P	O
Pearly razorfish	-	P	-
Emerald parrotfish	U	O	O
Striped mullet	A	A	A
White mullet	U	P	O
Fantail mullet	O	P	C

	Charlotte Harbor	Coastal Zone Between	Tampa Bay
Mountain mullet	-	-	R
Great barracuda	P	A	C
Northern sennet	R	C	P
Southern sennet	R	-	R
Atlantic threadfin	R	-	R
Spotfin jawfish	-	U	-
Mottled jawfish	P	P	-
Sand stargazer	R	-	R
Southern stargazer	R	C	U
Marbled blenny	O	P	R
Banner blenny	-	P	-
Banded blenny	R	-	-
Florida blenny	O	C	O
Seaweed blenny	P	A	P
Crested blenny	P	P	P
Feather blenny	U	C	O
Highfin blenny	P	C	-
Spotfin dragonet	-	P	-
Spotted dragonet	-	-	P
Seminole goby	-	P	-
Emerald goby	P	P	-
Highfin goby	R	P	-
Clown goby	O	A	C
Darter goby	-	A	P
Frillfin goby	U	C	O
Naked goby	U	P	U
Code goby	O	A	A
Crested goby	U	P	-
Green goby	R	P	O
Spotted goby	-	-	R
Twoscale goby	-	-	R
Tiger goby	P	P	P
Blue goby	-	-	P
Sharptail goby	-	P	O
Pink wormfish	U	R	R
Atlantic cutlassfish	-	P	A
Wahoo	-	-	R
Blackfin tuna	-	R	R
Spanish mackerel	O	C	C
Chub mackerel	-	-	P
King mackerel	P	O	O
Harvestfish	U	P	U
Butterfish	U	-	U
Man-of-war fish	-	-	-
Barbfish	P	A	U
Smoothhead scorpionfish	P	R	P
Spotted scorpionfish	P	-	-
Leopard searobin	O	A	O
Bighead searobin	O	A	O
Bandtail searobin	-	-	P
Blackfin searobin	-	-	P
Bluespotted searobin	R	P	R
Ocellated flounder	U	P	U
Spotted whif	R	P	-
Fringed flounder	O	A	U
Gulf flounder	U	A	U
Dusky flounder	-	P	P
Spotfin flounder	-	-	P
Eyed flounder	-	-	P
Bothus robinsi	-	-	P
Paralichthys oblongus	O	-	-
Hogchoker	C	P	O
Lined sole	U	A	O
Naked sole	P	P	P
Blackcheek tonguefish	C	P	O
Jambeau	-	-	P
Gray triggerfish	P	C	P
Fringed filefish	P	C	O
Orange filefish	C	C	O
Planehead filefish	C	C	C
Scrawled cowfish	U	C	U
Smooth trunkfish	-	-	P
Trunkfish	P	P	R
Smooth puffer	P	C	O
Marbled puffer	-	P	U
Northern puffer	R	-	R
Southern puffer	U	P	U
Bandtail puffer	P	P	R
Striped burrfish	O	A	O
Balloonfish	-	P	U
Porcupinefish	P	P	R

In order of abundance, the 15 most common fish reported by Finucane and the seasons of largest juvenile catches were as follows:

Bay anchovy	Fall, winter, spring
Tidewater silverside	Summer, fall, winter, spring
Spot	Winter, spring
Pinfish	Winter, spring
Silver perch	Summer, fall, winter, spring
Silver jenny	--
Striped mullet	Winter, spring
Longnose killifish	Fall
Sheepshead killifish	Fall
Spotfin mojarra	--
Rainwater killifish	--
Scaled sardine	--
Goldspotted killifish	--
Gulf killifish	Fall
Rough silverside	--

Recently in the Charlotte Harbor study area, bay anchovy, tidewater silverside, and striped mullet were caught with the greatest consistency and/or abundance (TI 1977). Relatively large but sporadic catches of rough silverside, spot, pinfish, mojarras, and killifish were also noted. Shorezones at the mouths of the Peace and Myakka rivers are dominated in January and February by juvenile spot and during the spring by sheepshead minnow, bay anchovy, tidewater silverside, and striped mullet. Bay anchovy and mullet generally decline in summer and fall, while tidewater silverside and striped and spotfin mojarra increase. In shorezones of the middle reaches of the harbor, pinfish and silver perch replace mullet and bay anchovy as dominant forms.

The ichthyofauna of the open waters of the estuary comprise a variety of pelagic and demersal (bottom-dwelling) fishes. Among the most common larger forms are sea catfish, gafftopsail catfish, Atlantic stingray, cownose ray, and bull shark. The most common smaller species are bay anchovy, juvenile sand seatrout and southern kingfish, and hogchoker. In a 1968-69 study of Charlotte Harbor, the dominant species were bay anchovy, pinfish, silver perch, silver jenny, and sand seatrout (Wang and Raney 1971); the investigation was made farther into the mid-harbor reaches than the aforementioned study, thus accounting for the greater proportions of pinfish, silver perch and silver jenny. Abundances generally decrease with low winter temperatures and with intrusion of low salinity water into the harbor during the rainy season (Wang and Raney 1971, TI 1977).

Rarely have investigations in the Tampa Bay and Charlotte Harbor estuaries included fish eggs and larvae, but there is indication in the Charlotte Harbor Estuary (TI 1977) of a protracted spawning season generally extending from February through September (into October in some cases) at water temperatures ranging from approximately 15 to 34°C (59 to 93°F). An apparent increase in spawning activity and the influx of marine larval forms into Charlotte Harbor during July coincides with the initial period of relatively high flows and reduced salinities in the upper portions of the estuary. The decreased salinities in this area create proper nursery conditions for young-of-the-year of many estuarine and marine species that utilize this area during the summer and fall. Predominant groups that have been represented in egg and/or larval catches are tidewater silverside, skilletfish, anchovies, drum and croaker, goby, hogchoker, and searobin.

Larvae of four major groups were represented among the macrozooplankton of Tampa Bay (Kelly and Dragovich 1967): anchovy, croaker, herring, and pipefish. All anchovy larvae were *Anchoa* spp. Identified sciaenids (croakers) were *Cynoscion* spp. and *Leiostomus xanthurus* (spot). All pipefish larvae were in the genus *Syngnathus*, and about 75 percent of the herring larvae were *Brevoortia* spp. Although there were some basic compositional differences between catches of fish eggs and larvae in Tampa Bay (Kelly and Dragovich 1967) and Charlotte Harbor (TI 1977), total numerical densities were similar.

SECTION 3

SIGNIFICANT SPECIES

A. THREATENED AND ENDANGERED SPECIES

Three sources were consulted to determine species occurring in the study area that are considered endangered or threatened as well as those considered rare or of special concern: the United States Department of Interior's list of endangered and threatened wildlife (USDI 1974), the wildlife code of the Florida Game and Fresh Water Fish Commission (FGFWFC 1976), and an inventory of rare and endangered biota of Florida compiled by the Florida Committee on Rare and Endangered Plants and Animals (FCREPA 1976). A discussion of pertinent laws and citizen actions that promulgated these lists appears in Volume VI, Section 5, along with definitions of the species' designations. The listed aquatic species (excluding birds, which are discussed in Volume VI, Section 5) that occur or have occurred in the study area are presented in Table 3.1. Volume VI, Section 5, contains additional information on several of the land-nesting aquatic vertebrates included in the table.

Table 3.1. Aquatic and Semiaquatic Species Reported from Study Area and Considered Endangered, Threatened, Rare, or of Special Concern*

Species	Status
Atlantic geoduck (*Panopea bitruncata*)	Rare (FCREPA)
Mangrove crab (*Aratus pisonii*)	Threatened (FCREPA)
Atlantic sturgeon (*Acipenser oxyrhynchus*)	Threatened (FCREPA)
Rivulus (*Rivulus marmoratus*)	Threatened (FCREPA)
Opossum pipefish (*Oostethus lineatus*)	Rare (FCREPA)
Suwannee cooter (*Chrysemys concinna suwanniensis*)	Threatened (FGFWFC, FCREPA)
Atlantic leatherback turtle (*Dermochelys coriacea*)	Endangered (USDI), Rare (FCREPA)
Atlantic ridley (*Lepidochelys kempii*)	Endangered (USDI, FGFWFC, FCREPA)
Atlantic green turtle (*Chelonia mydas mydas*)	Endangered (USDI, FGFWFC, FCREPA)
Atlantic hawksbill (*Eretmochelys imbricata imbricata*)	Endangered (USDI, FGFWFC, FCREPA)
Atlantic loggerhead (*Caretta caretta caretta*)	Threatened (FGFWFC, FCREPA)
American alligator (*Alligator mississippiensis*)	Threatened (USDI, FGFWFC), Special Concern (FCREPA)
Manatee (*Trichechus manatus*)	Endangered (USDI), Threatened (FGFWFC, FCREPA)

*Exclusive of a number of species of birds that are also dependent on aquatic habitat. They are discussed in Section 5 of Volume VI.

1. Atlantic Geoduck

This is a relatively large marine bivalve (shell length to 23 centimeters, or 9.2 inches) that has been collected infrequently from most areas of the Carolinian zoogeographic province (North Caroline to Texas); it occurs in depths ranging from intertidal to as much as 48 meters (158 feet). Although presumed to be distributed throughout the Charlotte Harbor and Tampa Bay areas (FCREPA 1976), living specimens from Florida are known with certainty from only Duval and St. Johns counties. Dead shells have been reported from Tampa Bay (FCREPA 1976, Robertson 1963) and from Charlotte Harbor (FCREPA 1976), but

FCREPA points out that most such shells are old and worn and "could represent once viable populations, no longer present in certain areas, whose shells are now being exposed by erosional action associated with rising sea level."

2. The Mangrove Crab

The small, agile, brightly colored mangrove crab is generally restricted to mangrove areas where it spends its life foraging for food among the branches of mangrove trees, especially red mangrove (FCREPA 1976). It is considered by FCREPA to be threatened because the tropical mangroves of Florida (e.g., those in the Keys or Southern and Central Coastal Florida) are its only continental U.S. habitat, and that habit is threatened by development.

3. Atlantic Sturgeon

This species is represented along the Gulf Coast by a distinct subspecies *(Acipenser oxyrhynchus desotoi)*, which apparently once supported a small fishery in Tampa Bay area. According to Townsend (1902) as cited by Springer and McErlean (1961), the catch in Tampa Bay during the winter of 1886-87 was about 1500 sturgeon and the following season yielded 2000 but the next season only 7 fish. "... the fishery was then abandoned." FCREPA (1976) relates that "there is no question that the species is severely depleted, or absent, from some areas where it once occurred, as for example Tampa Bay." Although a thorough review of relevant data reveals no recent record of this species within the study area, FCREPA reports that a small commercial fishery for sturgeon in the lower Suwannee River has remained farily stable for the past 20 years, indicating that the species is in no particular danger.

4. Rivulus

The rivulus *(Rivulus marmoratus)* is the only representative of the genus *Rivulus* in North America. Small (maximum length of approximately 60 millimeters, or 2.4 inches), it closely resembles the killifishes of the genus *Fundulus* and can reproduce as a synchronous self-fertilizing hermaphrodite. In Florida, rivulus has occurred approximately seven times (FCREPA 1976) in small catches (usually less than five individuals) at shallow depths [usually about 0.5 meters (1.7 feet)] in ditches and bays associated with saltmarsh or estuarine mangrove communities. The only collection in the study area has been near the mouth of Tampa Bay in Manatee County. FCREPA states that "although there is no direct evidence that the species is endangered in the state, its habitat (estuarine boundaries) is vulnerable to development and other types of destruction."

5. Opossum Pipefish

This pipefish, a relatively large species with a maximum standard length of about 175 millimeters (approximately 7 inches), occurs in brackish and freshwater habitats in a range extending from the southeastern United States to Brazil (FCREPA 1976). It has been caught in several areas on Florida's east coast (FCREPA 1976), but the only record from Florida's Gulf Coast is a single immature specimen taken near the mouth of Tampa Bay (Powell et al 1972). FCREPA's basis for classifying the opossum pipefish as rare is that "it has been recorded so few times from Florida, despite numerous collections from seemingly suitable habitats...."

6. Suwannee Cooter

This aquatic turtle is restricted to certain rivers and spring runs draining into the Gulf of Mexico. It is almost completely herbivorous, feeding primarily on *Naias*, *Sagittaria*, and *Ceratophylum* (FCREPA 1976); in brackish habitats it feeds largely on turtle grass (*Thalassia*). In Florida, the presumed range of the Suwannee cooter extends from the Apalachicola River delta southeast along the west coast of the peninsula to the Alafia River. The FGFWFC as well as FCREPA consider it to be threatened. FCREPA bases its classification on the "considerable reduction in population density the past decade." Only a few individuals are seen today in areas where hundreds could be seen just a few years ago. Although there is no organized market for them, they are continuously captured and eaten. The high density of sport boats on the rivers makes these conspicuous turtles particularly susceptible to exploitation and harassment. The habitat has been degraded in several rivers with the result that food plants have diminished or disappeared almost entirely."

7. Atlantic Leatherback

The largest of all marine turtles is the Atlantic leatherback, which weighs 295 to 591 kilograms (650 to 1300 pounds) as an adult. Distribution of this pelagic species is worldwide. Major nesting grounds are in Surinam and French Guiana. In Florida, nesting has been infrequent, primarily on the

Atlantic Coast, although nesting records exist for Walton and Odaloosa counties on Florida's west coast (FCREPA 1976). The species is listed by USDI as endangered but is considered merely rare by FCREPA, since "there are no records of this turtle ever having been common in Florida."

8. Atlantic Ridley

This marine turtle is characterized by a carapace that is usually broad in relation to its length. Mature individuals occur only in the Gulf of Mexico, but immature specimens have been collected along the Atlantic Coast of the U.S. and infrequently along European shores (FCREPA 1976). Perhaps the most vulnerable feature of this species is the restriction of the entire nesting population to one small area, which is approximately 16 kilometers (10 miles) of beach between Rancho Nuevo and Boca San Vincente in the state of Tamaulipas, Mexico. The basis for classifying the Ridley as endangered is its observed decline from about 40,000 in 1947 to about 2,000 in 1970.

9. Atlantic Green Turtle

This is a widely distributed species with several named subspecies. A herbivore, it is relatively large, with mature females weighing from 114 to 130 kilograms (250 to 285 pounds). It was once abundant in the Caribbean but now the only major nesting grounds are Tortuguero, Costa Rica, and Aves Island in the East Caribbean, with dispersal from these sites throughout most of the Caribbean (FCREPA 1976). Nesting in Florida was probably once widespread but today appears confined to the east coast, with only occasional reports of nesting on the lower west coast. The plight of this species, also considered by USDI and FGFWFC to be endangered, is succinctly characterized by FCREPA: "This species is the source of most turtle steak and turtle soup and has been intensively exploited for centuries in the Caribbean. Recently, commerce in flipper skins for leather and the oil for cosmetics also has developed. While once probably abundant in Florida, the current population is estimated to contain no more than 50 mature females. The species, like all sea turtles, is now legally protected within Florida waters, but an active fishery exists in much of the Caribbean."

10. Atlantic Hawksbill

One of the smaller sea turtles, mature females of this species generally weigh a little over 45 kilograms (100 pounds). It is distributed throughout the tropical waters of the world and nests on scattered shores throughout the caribbean. It generally is associated with reef communities where the adults feed on mollusks, crustaceans, and marine algae (FCREPA 1976). The hawksbill is the least studied of the marine turtles, so little is known of its life history. It is an infrequent visitor to Florida waters, and records show that only two nests have been observed in Florida although juveniles are occasionally observed on reefs off the southeast coast and the Florida Keys. Centuries of exploitation for "tortoise shell" used in jewelry and inlay work have resulted in the hawksbill being now considered endangered throughout the world.

11. Atlantic Loggerhead

This turtle is distributed throughout the temperate and subtropical waters of the world, nesting primarily on the beaches of eastern Australia, southeastern Africa, and southeastern United States (from North Carolina through Florida and, to a lesser extent, on islands off the Gulf states) (FCREPA 1976). Population decline has been attributed to erosion and ocean-front development rendering former nesting beaches unsuitable, the loss of large numbers of young because of predation by raccoons and disorientation (generally caused by beachfront lighting), and the drowning of many adults and subadults by shrimping activities near nesting beaches. FCREPA indicates tnat both range and population size appear to be decreasing in Florida.

12. American Alligator

Both the USDI and FGFWFC classify the American alligator as threatened, but FCREPA considers it a species of special concern. From the time when exploitation of its hide began in earnest (about 1870) until the animal became protected by law in the late 1960s, an estimated 10,000,000 alligators were killed (FCREPA 1976). Because of legal protection and, in part, population resiliency, the reptile's numbers have now increased to the point that FCREPA considers the animal "not seriously threatened" in Florida; however, the

FGFWFC considers it a threatened species, so it remains legally protected in Florida. The alligator is distributed in wetland and aquatic habitats throughout the state of Florida and is common in the study area.

13. Manatee

As early as 1895, concern was expressed for the extinction of the manatee in Florida (Moore 1951). Its original distribution in the United States extended from the coastal waters and lagoons of North Carolina to the southern coastline of Texas (USDI 1974) and Moore, in 1951, showed it to be distributed throughout Florida. Although the state began protecting the manatee in 1927, not until 42 years later was the Florida law supported by the Endangered Species Conservation Act of 1969 (PL 91-135; 83 Stat. 884) and then the federal Marine Mammal Protection Act of 1972 (PL 92-522; 86 Stat. 1027). Recent concern for the Florida manatee has prompted the USDI to designate certain areas where manatee occur in Florida as "critical habitat." A good portion of this critical habitat is located within the study area: the Peace River downstream from the Florida State Highway 760 bridge and the portion of Charlotte Harbor north of the Charlotte-Lee County line (Federal Register 1975). Today, an estimated 1000 manatee remain (Campbell and Powell 1976). The preferred habitat of the manatee includes shallow saltwater bays and fresh or brackish waters of coastal rivers, as well as warm inland springs during winter (Moore 1951, Hartman 1971). The manatee eats a variety of water plants but prefers succulent, submerged plants to fibrous grasses and rushes (Vietmeyer 1967); floating aquatics such as water hyacinth are virtually ignored (Hartman 1971). Adults are known to comsume as much as 45 kilograms (100 pounds) of aquatic vegetation each day, a grazing efficiency that would keep a 0.15-hectare (3.7-acre) area clear of aquatic vegetation (Stephens 1972).

The future of the manatee is questionable, although there is no evidence of recent decline (USDI 1974). Past declines have been attributed to hunting by man for their flesh, mass slaughter for sport, pneumonia caused by freezing weather, and silting of coastal feeding grounds (USDI 1974). The most recent threat to the manatee appears to be pollution and motor boats (Hartman 1971). Recent studies indicate that nearly half of all manatee killed in Florida between 1974 and April 1976 were killed by boats or barges; natural mortality appears comparatively low (Campbell and Powell 1976).

A careful consideration of the aforementioned species, status, habitat requirements, and respective frequencies of occurrence and abundance in the study area and the nature of potential environmental alterations accompanying further development of the central Florida phosphate industry indicates that the Suwannee cooter, American alligator, and manatee are the principal species of endangered, threatened, or rare status that should be addressed in the environmental impact assessment.

B. COMMERCIALLY OR RECREATIONALLY IMPORTANT SPECIES

1. Freshwater

There are no freshwater invertebrates of significant commercial or recreational value in the study area. There is, however, a considerable freshwater fishery resource. The study area has many lakes, streams, and coastal rivers that support commercial and sport fisheries. While many of these water bodies are inhabited by naturally established fish communities, a considerable number of lakes and ponds are maintained by fisheries management. Additionally, increasing numbers of phosphate pits have recreational potential, and many have been transformed into private and/or public fish management areas and parks.

Gamefishes in the area include largemouth bass, Florida largemouth bass, black crappie, snook, redear sunfish, bluegill, longear sunfish, warmouth, spotted sunfish, redfin pickerel, striped bass, hybrid striped bass, sunshine bass, and redbreast sunfish. (Distributions and abundances in both lotic and lentic habitats have already been discussed in Section 2.) Although not classified as gamefishes, the white and channel catfishes are also actively sought by sport fishermen in the study area.

Central Florida's commercial fisheries for catfish generally are concentrated in the upper and middle reaches of the streams. Those for estuarine migrants are concentrated in the lower reaches. Among the estuarine migrants are sea catfishes, mullet, jacks, sandperch, red drum, sheepshead, and seatrout. There are also commercial fisheries on a number of natural and man-made lakes and impoundments throughout the study area, especially in Polk and

Hillsborough counties. These fisheries are managed through a process of licensing, catch reports, gear and locality specifications, and enforcement regulations. The commercial fishermen generally are permitted to take all nongame species i.e., all forage (bait) species, e.g., seminole killifish and golden and taillight shiners; catfishes, including the channel and white catfishes and the yellow and brown bullheads; gizzard and threadfin shads; and all exotic fishes. A member of the latter contributing most notably to the freshwater commercial catch of the area is the blue tilapia, which has established healthy populations in a number of Polk and Hillsborough county lakes and impoundments. Recent nettings of tilapia from several Polk County lakes yielded a harvest of more than 226,360 kilograms (500,000 pounds) boosting the economy of the retail fish market by an estimated $445,000 (FGFWFC 1977).

Florida's commercial catch of freshwater species (excluding those handled by marine dealers) during 1975 was approximately 5,000,000 kilograms (11,100,000 pounds) worth nearly $3,000,000 to the fishermen. The 1975 annual catch was 13 percent higher than that of 1974. Catfish accounted for 87 percent of the total catch and 94 percent of the total value (Florida Department of Natural Resources 1975b).

A number of investigations (case histories), especially those of the Florida Haul Seine Project (FGFWFC 1975), have indicated that commercial removal of nongame fishes and stunted gamefishes effectively improves the existing sport fishery on a number of Polk County lakes, including Parker, Banana, Lulu, Effie, and Hancock.

2. Estuarine/Marine

While the study area's fresh waters have substantial commercial and recreational opportunities, its estuarine waters have outstanding commercial and recreational resources. Both the Tampa Bay and Charlotte Harbor estuaries are productive and abundant in species of commercial and recreational value.

Marine and estuarine fishes of recreational value within the study area include:

- Ladyfish
- Tarpon
- Bonefish
- Southern hake
- Snook
- Jewfish
- Speckled hind
- Rock hind
- Red grouper
- Black grouper
- Red hind
- Gag
- Yellowfin grouper
- Black sea bass
- Cobia
- Bluefish
- Blue runner
- Crevalle jack
- Greater amberjack
- Florida pompano
- Permit
- Dolphin
- Red snapper
- Gray snapper
- Lane snapper
- Yellowtail snapper
- Tripletail
- White grunt
- Bluestriped grunt
- Sheepshead
- Pinfish
- Spotted seatrout
- Sand seatrout
- Red drum
- Black drum
- Silver perch
- Atlantic croaker
- Atlantic spadefish
- Great barracuda
- Blackfin tuna
- Spanish mackerel
- King mackerel
- Little tunny
- Gulf flounder
- Fourspot flounder
- Gray triggerfish

Saltwater sport or game fishing in the study area comprises four relatively distinct types. The first and apparently the most popular is light inshore tackle fishing for such species as spotted seatrout, red drum, sheepshead, tarpon, snook, gray snapper, and other inshore fishes. The Peace River estuary at Punta Gorda and the Myakka River estuary a short distance north of El Jobean reportedly produce good tarpon fishing from May through September, peaking around July. One of the most famous areas for big tarpon is Boca Grande Pass, which is about 52 kilometers (33 miles) southwest of Punta Gorda where the estuarine waters of Charlotte Harbor mingle with the Gulf. According to a recent survey of pier fishermen in the Tampa Bay area (U.S. Army Corps of Engineers 1974), the most commonly caught species and seasons of greatest catch are as follows:

Snook	Summer
Silver perch	Winter, spring
Sheepshead	Winter, spring
Spotted seatrout	Spring
Atlantic croaker	Spring
Grunts	Spring
Spanish mackerel	Summer, fall, winter, spring
Crevelle jack	Summer, fall, winter
Gulf flounder	Fall, spring
Red drum	Summer, fall, winter
Black drum	Fall, winter
Whitings	Summer, fall, winter, spring
Sand seatrout	Fall, winter, spring
Pinfish	Summer, fall, winter, spring
Atlantic spadefish	Summer
Gray snapper	Summer

The second type of sports fishing is offshore trolling in the Gulf from charter or private boats. Sailfish, dolphin, marlin, Spanish and King mackerel, and wahoo are among the primarily offshore or Gulf species sought. The third type is bottom fishing from private and charter boats in the inshore bays and passes or offshore rocky reefs. Grunts, snappers, and groupers are the main catches. Steadily increasing in popularity among fishermen using the inshore byas and estuaries is bridge fishing from the numerous causeways and highway bridges that are often specifically designed to accommodate fishermen. This type of fishing is generally quite successful in capturing sheepshead, red drum, spotted seatrout, snook, and other inshore species that apparently congregate around such structures.

Sport fishing is a tremendous economic asset to Florida: it earned $350,000,000 in 1971 and over the preceeding 7 years had grown at a rate of $25,000,000 per year (U.S. Army Corps of Engineers 1974). In 1971, an estimated, 8,800,000 man-days were spent in saltwater sport fishing. More than half of the saltwater sport fishing occurs along the Gulf Coast (U.S. Army Corp of Engineers 1974) , and much of that undoubtedly is concentrated near the tourist and population centers of the Tampa Bay and Charlotte Harbor areas.

Approximately 79 fish species and seven invertebrates (shellfish) species of some commercial value are found in at least one life stage in the study area's estuarine waters; 30 of the species in 1975 had an annual dockside value exceeding $1,000 in at least one of the shoreline counties in the study area (Sarasota, Charlotte, Manatee, Hillsborough) (Florida Department of Natural Resources 1975b) and are thus considered commercially important:

Finescale menhaden
Gulf menhaden
Yellowfin menhaden
Atlantic thread herring
Red grouper
Gag
Scamp
Bluefish
Crevalle jack
Florida pompano
Permit
Gray snapper
Vermilion snapper
Striped mojarra
Spotfin mojarra
Silver jenny
Spotted seatrout
Sand seatrout
Spot
Atlantic croaker
Red drum
Black drum
Striped mullet
White mullet
Fantail mullet
Spanish mackerel
King mackerel
Blue crab
Stone crab
Pink shrimp

Those bringing less than $1,000 annually are of marginal commercial value and include the following:

- Cownose ray
- Lady fish
- Scaled sardine
- Striped anchovy
- Bay anchovy
- Inshore lizardfish
- Sea catfish
- Gulf toadfish
- Shortnose batfish
- Polka-dot batfish
- Southern hake
- Halfbeak
- Tidewater silverside
- Gulf pipefish
- Lined seahorse
- Southern sea bass
- Sand perch
- Rock hind
- Sharksucker
- Blue runner
- Atlantic bumper
- Leatherjacket
- Lane snapper
- Yellowtail snapper
- White grunt
- Pigfish
- Grass Porgy
- Pinfish
- Silver perch
- Southern kingfish
- Atlantic spadefish
- Southern sennet
- Feather blenny
- Barbfish
- Leopard searobin
- Bighead searobin
- Ocellated flounder
- Fringed flounder
- Gulf flounder
- Fourspot flounder
- Hogchoker
- Lined sole
- Blackcheek tonguefish
- Gray triggerfish
- Orange filefish
- Scrawled cowfish
- Northern puffer
- Southern puffer
- Striped burrfish
- Squid
- Conch
- Horseshoe crab
- Oysters
- Sand dollars

Commercial landing data for 1973-75 for the counties comprising Charlotte Harbor and Tampa Bay are summarized in Table 3.2. On a poundage basis, shrimp, mullet, grouper, red and black drum, pompano, spotted seatrout, spanish mackerel, red snapper, crevalle jack, sand perch (mojarra), sheepshead, blue crab, and stone crab represent the largest landings in the Tampa Bay-Charlotte Harbor area. Substantial landings of spiny lobsters from the study area also are reported, but the majority of lobsters are taken outside Florida waters and landed in Florida ports (Prochaska 1976). On a dollar basis, shrimp are by far the most important species landed. Recent shrimp landings in Florida, however, show a significant negative trend — a decrease of about 636 kilograms (1400 pounds) per year (Prochaska 1976) — attributed to a reduction in landings caught outside of Florida waters. Shrimp prices have generally trended upward, however, partially offsetting the economic effect of the downward trend in landings.

In addition to shrimp taken for consumption, there is also a sizable bait shrimp industry within the study area. Table 3.3 summarizes landings for bait shrimp, along with adult shrimp and stone and blue crabs in Hillsborough, Pinellas, and Manatee counties during 1966-72. Bait shrimping in Tampa Bay is principally in the western portions of Old Tampa Bay and lower Tampa Bay,

Table 3.2. Summary of 1973-75 Co
Study Area's Four Coa

	Hillsborough County						Manatee County						Sarasota County						
	1973		1974		1975		1973		1974		1975		1973		1974		1975
Fish Species	lb	$	lb	$	lb	$	lb	$	lb	$	lb	$	lb	$	lb	$	lb
Alewives	-	-	-	-	-	-	-	-	-	-	-	-	-	-	472	23	-
Amberjack	-	-	1,585	56	252	37	-	-	-	-	-	-	500	50	252	12	-
Angelfish	417	34	-	-	309	21	583	29	1,585	56	782	35	21	1	-	-	-
Barracuda	-	-	-	-	-	-	9,559	1,303	-	-	-	-	-	-	-	-	-
Blue runner or hardtail	-	-	2,123	297	-	-	-	-	2,123	297	51	2	77	4	23,691	3,493	-
Bluefish	-	-	25,161	3,375	-	-	-	-	25,161	3,375	39,145	5,660	15,374	2,080	-	-	12,317
Bonito	-	-	-	-	508	105	75	8	-	-	121	11	-	-	-	-	-
Catfish, fresh**	1,743	502	243	91	2,161	978	448	154	243	91	-	-	-	-	-	-	-
Catfish, salt	45	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cigarfish			-		-	-	-	-	-	-	-	-	-	-	50	5	-
Cobia	-	-	338	59	10	6	208	31	338	59	728	136	950	127	31,994	1,439	200
Crevalle (jacks)	7,322	296	236,175	13,869	8,523	456	503,180	28,630	236,175	13,869	284,892	18,276	57,014	2,993	-	-	4,560
Croaker	15	4	18,746	4,694	-	-	9,133	2,280	18,746	4,694	8,858	2,213	236	29	-	-	-
Dolphin	-	-	-	-	55	8	-	-	-	-	488	91	-	-	-	-	-
Drum, black	7,990	808	11,004	1,174	792	91	8,814	924	11,004	1,174	1,203	144	10,452	1,207	2,181	218	1,051
Drum, red	-	-	209,663	42,450	5,645	1,561	-	-	209,663	42,450	68,284	13,435	-	-	23,675	5,093	6,637
Flounders	282	91	1,425	287	281	84	2,196	442	1,425	287	504	94	601	137	158	30	167
Goatfish	-	-	1,139	774	-	-	-	-	1,139	774	-	-	-	-	-	-	-
Groupers and scamp	118,444	35,094	746,038	263,955	99,114	42,906	656,412	217,546	746,038	263,955	681,804	277,775	100,001	31,390	111,824	36,516	114,360
Grunts	11	3	9,650	3,860	147	27	228	53	9,650	3,860	220	35	-	-	-	-	-
Hogfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Jewfish	73	18	195	58	-	-	911	137	195	58	5,972	586	1,097	95	400	60	3,300
King mackerel	132	39	12,467	3,840	3,886	1,406	7,048	1,054	12,467	3,840	3,593	1,370	4,514	1,577	19,042	5,712	62
King whiting	729	71	2,543	478	1,567	156	4,847	928	2,543	478	1,679	377	394	47	-	-	131
Menhaden	-	-	265	43	-		107	18	265	43	-	-	-	-	-	-	-
Mullet, black	1,226,389	125,704	2,607,572	317,276	442,505	67,736	3,579,401	375,528	2,607,512	317,276	3,212,867	148,884	881,630	92,130	387,754	45,064	243,671
Mullet, silver	-	-	15,874	460	13,029	1,952	1,297	130	15,874	460	2,180	174	11,454	1,364	2,337	350	10,374
Permit	-	-	14,449	2,967	-	-	24,717	5,469	14,449	2,967	110,008	22,213	7,774	1,247	3,923	674	10,443
Pigfish	-	-	-	-	-	-	839	41	-	-	-	-	-	-	-	-	-
Pompano	443	527	60,355	68,173	568	726	48,253	53,097	60,355	68,173	97,420	109,715	38,524	42,707	32,321	37,855	21,915
Sand perch (mojarra)	17,857	3,487	7,469	1,114	11,744	2,543	9,924	1,353	7,469	1,114	1,853	281	19,041	2,665	10,342	1,531	4,337
Scup	-	-	10,740	1,728	66	10	-	-	10,740	1,728	7,764	1,334	-	-	-	-	-
Sea bass	331	70	-	-	279	62	-	-	-	-	-	-	-	-	-	-	-
Sea trout, gray	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sea trout, spot	31,090	12,066	134,038	50,645	19,051	9,257	128,134	43,398	134,038	50,645	81,940	33,264	33,629	11,932	-	-	20,164
Sea trout, white	60	15	2,874	566	-	-	1,740	262	2,874	566	8,343	2,701	3,774	587	23,568	9,258	-
Shad	-	-	-	-	706	42	-	-	-	-	-	-	-	-	-	-	615
Sharks	-	-	-	-	-	-	-	-	-	-	3,564	265	-	-	-	-	908
Sheepshead	4,535	716	4,859	607	1,200	209	21,064	2,559	4,859	607	5,292	811	8,796	1,098	14,148	1,982	9,987
Snapper, lane	-	-	-	-	14	11	100	50	-	-	-	-	-	-	-	-	-
Snapper, mangrove	89	41	2,774	1,228	408	188	2,051	676	2,774	1,228	2,017	905	1,341	473	2,249	751	105
Snapper, mutton	-	-	1,129	633	-	-	3,286	1,694	1,129	633	3,990	2,168	-	-	94	-	-
Snapper, red	15,035	13,137	394,756	335,027	36,080	31,649	371,287	189,100	394,756	335,027	229,536	197,479	17,712	14,571	44,812	37,770	59,363
Snapper, white	-	-	-	-	-	-	7,442	972	-	-	-	-	-	-	-	-	-
Snapper, vermilion	-	-	2,196	1,462	-	-	9,067	6,352	2,196	1,462	14,964	11,417	-	-	-	-	-
Snapper, yellowtail	24	12	124	62	-	-	237	118	124	62	3	1	-	-	16	-	-
Spanish mackerel	2,257	501	129,133	22,405	485	157	137,091	21,920	129,133	22,405	159,636	29,320	198,198	28,798	64,867	11,689	21,417
Spanish sardines	-	-	-	-	-	-	-	-	-	-	137,775	13,776	-	-	-	-	-
Spot	3,569	428	20,889	3,422	127	20	8,979	1,345	20,889	3,422	9,203	1,382	304	45	602	110	20
Swordfish	-	-	798	488	-	-	-	-	798	488	-	-	-	-	-	-	-
Tenpounder (ladyfish)	-	-	3,116	104	-	-	268	13	3,116	104	1,875	84	220	11	878	42	201
Tilapia (Nile perch)	-	-	-	-	386	56	-	-	-	-	641	69	-	-	-	-	-
Tilefish	-	-	293	117	-		2,448	478	293	117	4,338	863	-	-	-	-	-
Tripletail	-	-	-	-	4,100	30	-	-	-	-	-	-	-	-	-	-	-
Wahoo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Warsaw	-	-	46,601	11,340	-	-	33,742	6,765	46,601	11,340	32,720	8,086	-	-	-	-	-
1-Unclassified-food	13,637	1,715	217,252	27,363	3,904	618	121,629	14,729	217,252	27,363	129,686	17,717	31,332	3,719	11,970	1,532	7,532
2-Unclassified-misc.	1,515	70	2,300	109	5,465	317	625	39	2,300	109	18,890	415	220	11	-	-	125
Redfish (channel bass)**	12,624	2,421	-	-	-	-	170,474	31,912	-	-	-	-	16,371	3,344	-	-	-
Trash fish**	1,515	70	-	-	-	-	250	8	-	-	-	-	-	-	-	-	-
Total fish	1,466,658	197,874	4,958,351	1,186,656	659,747	163,415	5,697,459	1,006,501	4,958,351	1,186,656	5,374,902	1,223,584	1,461,331	244,488	813,620	201,207	553,962
Clams hard	52,863	8,473	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crabs, blue, hard	-	-	20,972	5,671	440,205	59,912	13,659	3,168	20,972	5,671	171,763	26,620	420	105	280	210	156,296
Crabs, blue, soft	-	-	-	-	540	387	-	-	-	-	-	-	-	-	-	-	-
Crabs, stone	-	-	2,340	1,800	-	-	26,930	19,505	2,340	1,800	5,662	4,660	36,520	25,008	-	-	860
Lobster, spanish	-	-	-	-	150	99	-	-	-	-	-	-	-	-	-	-	-
Lobster, spiny (crawfish)	250,000	267,500	-	-	-	-	-	-	-	-	-	-	477	510	-	-	-
Shrimp, bait***	-	-	-	-	-	-	-	-	-	-	43,679	48,918	-	-	-	-	-
Shrimp, rock	-	-	-	-	807,140	387,455	-	-	-	-	-	-	-	-	-	-	-
Shrimp, east coast	-	-	-	-	3,578	5,392	-	-	-	-	-	-	-	-	-	-	-
Shrimp, campeche	-	-	-	-	134,164	148,895	-	-	-	-	-	-	-	-	-	-	-
Shrimp, central west coast	-	-	41,202	44,102	1,437,299	1,570,302	-	-	41,202	44,102	77,777	100,110	-	-	-	-	-
Shrimp, tortugas	1,804,004	1,754,779	1,595	1,932	373,988	400,448	52,764	57,221	1,592	1,932	-	-	-	-	-	-	-
Shrimp, upper west coast	-	-	16,879	14,630	429,449	547,474	-	-	16,879	14,630	20,802	32,465	-	-	-	-	-
Squid	267	80	-	-	249	81	-	-	-	-	-	-	-	-	-	-	-
Total Shellfish	2,107,134	2,030,832	82,988	68,135	3,626,762	3,120,345	92,853	79,894	82,988	68,135	319,683	212,773	37,417	25,623	280	210	157,156
Grand Total	3,373,792	2,228,706	5,041,339	1,254,791	4,286,509	2,283,760	5,790,322	1,086,395	5,041,339	1,254,791	5,694,585	1,436,357	1,498,748	270,111	813,900	201,417	711,118

[*] Florida Department of Natural Resources (1973)
Florida Department of Natural Resources (1974)
Florida Department of Natural Resources (1975b)

[**] Listed in category in 1973 only.

[***] Listed in category in 1975 only.

Table 3.2. Summary of 1973-75 Commercial Landings for Study Area's Four Coastal Counties*

Manatee County					Sarasota County						Charlotte County					
973	1974		1975		1973		1974		1975		1973		1974		1975	
$	lb	$	lb	$	lb	$	lb	$	lb	$	lb	$	lb	$	lb	$
-	-	-	-	-	-	-	477	23	-	-						
-	-	-	-	-	500	50	252	12	-	-						
29	1,585	56	782	35	21	1	-									
1,303	-	-	-		-	-	-									
-	2,123	297	51	2	77	4	23,691	3,493	-				30	16	3,798	549
-	25,161	3,375	39,145	5,660	15,374	7,080	-	-	12,017	2,362	3,975	366	95,083	4,027	136,777	1,427
8	-	-	121	11	-	-	-	-	-	-	108	15				
154	243	91	-	-		-	-	-	-	-	60	25	136	47	19	11
-	-	-	-	-	-	-	-	-	-	-	164	16				
-	-	-	-	-	-	-	50	6	-	-						
31	338	59	728	136	950	127	31,494	1,439	200	28	73	3			108,469	6,764
28,630	236,175	13,869	284,892	18,276	57,014	7,993	-	-	4,560	284	125,126	8,276	179,086	19,297		
2,280	18,746	4,694	8,858	2,213	236	29	-	-	-	-						
-	-	-	488	91	-		-	-	-	-					8	14
924	11,004	1,174	1,203	144	10,452	1,207	2,181	218	7,051	120	5,913	307	4,237	356	4,404	432
-	209,663	42,450	68,[illegible]	13,435	-		23,675	5,093	8,637	2,332			171,368	23,061	50,837	13,142
442	1,425	287	504	94	601	137	156	32	167	91	5,550	507	4,727	644	1,840	150
-	1,139	774	-	-	-		-		-	-						
217,546	746,038	263,955	681,804	277,775	100,001	31,390	111,024	38,516	114,360	36,701	20,422	6,942	14,230	1,488	29,978	12,047
53	9,650	3,860	220	35	-				-							
-	-	-	-	-	-		-		-		166	17				
137	195	58	5,972	586	1,097	95	400	92	5,000	130	1,066	171	1,008	159	1,066	172
1,054	12,467	3,840	3,593	1,370	4,514	1,577	19,042	6,717	82	9					416	166
928	2,543	478	1,679	377	394	47	-		131	16	12,291	5,817	4,800			
18	265	43	-	-	-											
375,528	2,607,512	317,276	3,212,867	140,864	881,630	92,130	387,754	49,064	747,671	86,765	2,047,657	608,800	2,853,364	383,440	2,278,558	[illegible]
130	15,874	460	2,180	174	11,454	1,364	2,337	350	50,374	1,563	110	11				
5,469	14,449	2,967	110,008	22,213	7,774	1,247	4,923	674	35,443	1,480	-					
41	-	-	-		-						35	4				
53,092	60,355	68,173	97,420	109,715	38,524	42,707	42,327	37,408	21,031	26,258	29,417	37,260	46,679	37,746	44,036	52,190
1,353	7,469	1,114	1,853	291	19,041	2,665	10,342	1,531	4,337	684	88,225	8,607	54,838	7,096	79,407	13,602
-	10,740	1,728	7,764	1,334	-								687	125		
-	-	-	-	-	-											
-		-		-	-								753	18		
43,398	134,038	50,645	81,940	33,264	33,628	11,992	-		20,164	8,279	109,317	106,753	141,628	99,692	164,090	64,912
262	2,874	566	8,343	2,701	3,774	587	23,568	4,250	-		304	116	6,422	7,364	760	62
-	-	-			-				473	38						
-	-	-	3,564	265	-				508	41	15	4	28	3		
2,559	4,859	607	5,292	811	8,796	1,098	14,148	1,992	9,907	1,483	81,524	4,332	77,248	6,079	38,532	14,347
50	-	-	-		-						12	1	82	6		
676	2,774	1,228	2,017	905	1,341	473	2,249	751	105	41	7,688	7,929	4,876	1,366	7,090	1,417
1,694	1,129	633	3,990	2,168	-	-	94				1,205	424				
189,100	394,756	335,027	229,536	197,479	17,712	14,571	44,812	37,770	58,361	51,596	4,323	2,400	411	751	170,119	8,297
972	-	-	-	-	-						334	530				
6,352	2,196	1,462	14,964	11,417	-											
118	124	62	3	1	-		16				2,138	789				
21,920	129,133	22,405	159,636	29,320	199,198	26,798	64,867	11,609	21,417	4,097	64,459	9,096	222,536	17,092	49,416	16,094
-	-	-	137,775	13,776	-	-			-							
1,345	20,889	3,422	9,203	1,387	304	45	602	110	20	4	1,846	184	1,747	174	622	60
-	798	488	-	-	-	-			-							
13	3,116	104	1,875	84	220	11	878	42	203	4	-					
-	-		641	69	-	-	-	-	-	-						
478	293	117	4,338	863	-	-	-	-	-	-						
-	-	-	-	-	-	-	-	-	-	-	-	-				
-	-	-	-	-	-	-	-	-	-	-	-	-		-	73	18
6,765	46,601	11,340	32,720	8,086	-	-	-	-	-	-	-	-	112	50	16	4
14,729	212,262	77,363	129,686	17,717	31,332	3,719	11,970	1,532	7,532	972	19,116	1,850	28,960	3,014	35,975	5,004
39	2,300	109	18,890	415	220	11	-	-	125	6	75	4	-		-	
31,912	-	-	-	-	16,371	3,344	-	-	-	-	131,481	26,375	-			
8	-	-	-	-	-	-	-	-	-	-	-		-			
006,501	4,950,351	1,186,656	5,374,902	1,223,564	1,461,331	244,488	813,620	201,207	553,962	177,479	3,667,500	524,800	3,690,449	547,557	2,939,408	525,913
-	-	-	-	-	-	-	-	-	-	-	-	-	-			
3,168	20,972	5,671	171,763	26,620	420	105	280	210	156,296	19,719	349,461	-	328,261	38,386	258,085	31,771
-	-	-	-	-	-	-	-	-	-	-	-	-	36	32	82	79
19,505	2,340	1,800	5,662	4,660	36,520	25,008	-	-	860	645	35,750	23,076	68,539	51,451	78,799	28,427
-	-	-	-	-	-	-	-	-	-	-	-		-	-		
-	-	-	-	-	477	510	-	-	-	-	22,964	24,571	4,161	5,076		
-	-	-	43,679	48,918	-	-	-	-	-	-	-	-	-	-	4,695	5,712
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4,667	2,634
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	41,202	44,102	77,777	100,110	-	-	-	-	-	-	-	-	10,658	11,861	106	126
57,221	1,592	1,932	-	-	-	-	-	-	-	-	120,772	129,013	199,653	166,186	157,878	189,076
-	16,879	14,630	20,802	32,465	-	-	-	-	-	-	-	-	251	96	4,988	7,318
-	-	-	-	-	-	-	-	-	-	-	84	10	7	-	410	71
79,894	82,988	68,135	319,683	212,773	37,417	25,623	280	210	157,156	20,364	528,740	218,151	611,866	274,088	455,636	261,709
086,395	5,041,339	1,254,791	5,694,585	1,436,357	1,498,748	270,111	813,900	201,417	711,118	197,843	4,196,240	742,951	4,302,715	821,645	3,395,044	787,622

the Boca Ciega Bay area, and a small area off Egmont Key (U.S. Army Corps of Engineers 1974). Although substantial bait shrimping is known to occur in Charlotte Harbor, no data on magnitude or distribution have been found. The bait shrimp industry in the study area is steadily declining primarily because of reduction of available habitat by dredge-and-fill operations (Saloman 1965).

Table 3.3. Landings of Bait Shrimp, Adult Shrimp, and Stone and Blue Crabs in Hillsborough, Pinellas, and Manatee Counties, 1966-72*

	Bait Shrimp		Adult Shrimp		Stone Crab		Blue Crab	
	Number	Value ($)	Pounds	Value ($)	Pounds	Value ($)	Pounds	Value ($)
1966	22,987,020	278,113	4,726,698	2,379,991	24,610	7,004	1,224,179	120,300
1967	22,916,521	294,167	3,670,401	1,894,864	12,967	5,272	758,959	50,254
1968	21,940,350	279,750	3,634,527	2,064,839	21,637	10,083	738,359	18,678
1969	25,175,900	229,626	3,390,538	1,895,001	78,558	44,515	199,573	23,756
1970	22,819,550	293,600	2,580,960	1,518,023	60,282	31,866	437,412	31,576
1971	15,699,600	202,211	1,677,213	1,159,792	23,218	12,064	274,117	23,710
1972	12,041,779	161,156	2,386,021	1,975,407	240,606	236,867	355,539	38,092

*U.S. Army Corps of Engineers (1974).

In addition to the highly sought fishes and shellfishes, a substantial number of incidental fishes as well as squid are part of the commercial fishery. The bulk of these fishes are byproducts of shrimp trawling as well as netting for more desirable species and generally are sold for consumption, ground for meal, rendered for oil, or sold or used as bait.

Immature life stages of 23 species of major importance in Gulf of Mexico commercial fisheries, including the five most important species, are known to use the Tampa Bay estuary as a nursery (Sykes and Finucane 1966).

Other species that may have commercial potential in the study area are the hard clam (Woodburn 1962, Menzel and Sims 1964, Taylor and Saloman 1970), lancelets (Taylor and Saloman 1966), the sunray venus and *Chione cancellata* clams (Taylor and Saloman 1970), the rangia marsh clam (Woodburn 1962), lugworms (Taylor and Saloman 1970), and turtle grass (Taylor and Saloman 1970). Conditions for clam culture in certain portions of the study area are favorable, but no large-scale enterprise has yet begun. The lugworm, presently dug from tidal flats, has become a species of commercial interest as a bait worm; preliminary findings indicate that in tank culture a 1-square meter (10-square foot) area of seidment can produce $25 worth of worms in 1 year (Taylor and Saloman 1970). Production was considerably less in a fenced natural area. Dried turtle grass is being investigated as a dietary supplement of sheep.

In reviewing the recreational and commercial aspects of the Tampa Bay and Charlotte Harbor estuarine systems, it is readily apparent that the biota of the two systems are a tremendous asset and should receive judicious consideration in any further development of the area.

C. NUISANCE OR PEST SPECIES

The same environmental features that provide the outstanding biotic resources of the fresh and salt waters of Florida also promote the possibilities of growth of certain native and exotic species populations to nuisance levels. Newly introduced (both intentionally and accidentally) species generally find an acquiescent habitat in which to proliferate; i.e., the species often find a suitable vacant or underexploited trophic level with few, if any, environmental impediments to population growth (e.g., predators, diseases, freezes, etc.). When exotic species enter trophic levels occupied by native species, they often displace the native forms and rearrange trophic levels for the entire ecosystem. Although the consequences of exotic introductions have been severe, the problems associated with nuisance growths of indigenous forms also have been substanstial.

1. Estuarine/Marine

The organism most devastating to the study area is a small single-celled alga, *Gymnodinium breve*. This minute, unarmored dinoflagellate is a common phytoplankter in estuarine and marine waters of the west coast of Florida. About every 3-5 years, the population of this organism "blooms" for largely unknown reasons, creating the condition known as "red tide." The blooms generally occur offshore but are transported to nearshore waters where physical conditions (e.g., wind and currents) concentrate the organisms further. At high concentrations, they impart a red coloration to the water and cause massive lethal intoxication to marine animals, resulting in severe economic impact. Nuisance manifestations of the red tide include extensive windrows of large numbers of decomposing fish (Steidinger and Ingle 1972), extensive losses of commercially valuable fish and shellfish (Quick and Henderson 1974, Simon and Dauer 1972), and devastation of benthic communities (Simon and Dauer 1972, Smith 1975); additionally, irritating aerosols produced in the surf cause respiratory problems for persons who are as far as 48-64 kilometers (30-40 miles) from the bloom (Martin and Martin 1976).

The economic consequences of the red tide are staggering. Florida recently experienced two major outbreaks, one during summer 1971 and the other during winter and early spring 1973-74. The former was of moderate severity and relatively short duration (3 months) but was widely publicized (Martin and Martin 1976); it affected seven coastal counties including those of the study area and caused an estimated loss to the tourist industry of approximately $18,000,000 and cleanup costs of approximately $2,000,000 (Habas and Gilbert 1974). The red tide of 1973-74 was widespread, sporadic, of prolonged severity, and occurred during the peak tourist season, but national publicity was minimal (Martin and Martin 1976); it damaged the tourist industry by an estimated $15,000,000 (Martin and Martin 1976). The severe magnitude of this nuisance is most apparent when you add to these costs the local commercial and recreational fishing industries' loss of revenue, losses on sale of imported fishes in Florida because of the halo effect, and the dollars spent on research to try to determine causes and control.

Another nuisance condition in the saline waters of the study area results from the death and deterioration of prolific growths of a marine red alga, *Gracilaria* spp. Not so widespread as the red tied, this nuisance condition appears to be restricted to the Hillsborough Bay portion of Tampa Bay where heavy growths of unattached and free-floating *Gracilaria* develop. *Gracilaria* represents 98 percent of the macroalgae crop in Hillsborough Bay but only 2 percent in Old Tampa Bay (FWPCA 1969). The nuisance condition usually is brought about by an unfortunate circumstance of timing: peak standing crops of *Gracilaria* generally occur near the end of the dry season and, with the onset of freshwater influx into the bay during the rainy season (usually around June), large quantities of *Gracilaria* are killed by the reduced salinities and deposited on beaches where they deteriorate (FWPCA 1969). Undesirable conditions accompanying deterioration of the *Gracilaria* include deoxygenation of surrounding waters, production of hydrogen sulfide and other noxious odors, and unsightly deposits on the beaches. The economic consequences of the *Gracilaria* nuisance are unknown, but the displeasure of the residents of the city of Tampa with the situation is apparently well documented (FWPCA 1969). The nuisance has prompted a series of investigations of abatement and rehabilitation measures.

Regarded as fouling organisms are barnacles and bivalves, which attach in numbers to ship surfaces and pilings to impede ship speed or damage watercraft that run against pilings. Bivalves and algal mats can clog submerged pipes, and any of a number of fouling organisms can entangle nets, propellers, or cables. Although there is no compilation of economic losses attributed to fouling organisms, it can be assumed that collectively their consequences are substantial in the study area.

There are no major nuisance or pest fishes species within the estuarine/marine waters of the study area but sport fishermen consider a number of fish species including searobins, mojarras, puffers, sea catfish, pinfish, and smaller sharks to be bait stealers; these, like horseshoe crabs, sharks, and rays, which occasionally clog or tear commercial nets, may be of minor nuisance potential.

2. Freshwater

Pest or nuisance organisms and conditions associated with the freshwaters of the study area include algal blooms, exotic hydrophytes, mosquitos, midges, the Asiatic clam, and a variety of native and exotic fishes. Abundances and associated problems generally vary locally.

The nutrient-rich waters and warm temperatures of the study area are conducive to the development of green and bluegreen algal blooms and attendant nuisance conditions. Although attached algae can bloom in the streams [e.g., *Rhizoclonium* in the upper Peace River (Ware 1969)], most algal bloom problems are associated with the lentic or standing waters. Algal blooms in the ponds, lakes, and impoundments may be manifested as heavy mat-like growths of filamentous green algae (e.g., *Spirogyra, Oedogonium, Pithophora)* that develop along the periphery of the water body or as benthic mats of filamentous bluegreen algae (e.g., *Anabaena, Oscillatoria, Nostoc*) that become dislodged from the bottom and concentrate along the shores. Another manifestation is the pea-soup appearance of phytoplankton blooms in the open waters of a lake or pond. Although visually displeasing, the shoreline and benthic mats of filamentous algae are generally of small consequence compared with the bloom of phytoplankton within a water body. Although water in the algal mat communities may be deoxygenated, the effects are often local and motile species can avoid the stressing conditions by moving elsewhere. When a phytoplankton bloom occurs, however, the entire water body generally is affected and the resident aquatic biota cannot avoid the stress conditions. Deoxygenation of the water column during evening hours or upon demise of the phytoplankton population typically accompanies the phytoplankton bloom. In addition, certain bluegreen algae, including *Anabaena* and *Microcystis*, often impart undesirable tastes and odors as well as potential toxicity to the waters. Fish kills and other ecological disruption may occur within the water body, and, most noticeable to man, surface water supplies become tainted with an undesirable taste, odor, or color.

Phytoplankters that reportedly bloom in lakes in the study area include the bluegreen algae *Anabaena*, *Oscillatoria*, and *Microcystis* and the diatom *Melosira* (Cowell et al 1975, Folit et al 1975). Other phytoplankters undoubtedly bloom in the area but are unreported because of the paucity of limnological studies in the study area.

More of potential rather than realized nuisance in the study area is the presence of the Asiatic clam *Corbicula*, a recently introduced lotic species that requires flowing water for acquisition of food. The major nuisance condition associated with this organism in other areas is the fouling of water conduits such as intakes for condenser cooling water for power plants. As mentioned, *Corbicula* was not reported in the Peace River as recently as 25 years ago but now (Lanquist 1953) is one of the prevalent benthic species there (Florida Department of Environmental Regulation 1975, TI 1977). It has been reported also in most of the other drainages in the study area. It was noted in particular abundance in the middle reaches of the Alafia River during the dry season (March 1977) field reconnaissance for this study.

Perhaps the most severe nuisance of the fresh waters of the study area is the prolific growth of exotic hydrophytes including water hyacinth, *Hydrilla*, and water milfoil. These hydrophytes, as well as others, proliferate readily in the nutrient-rich waters, clogging waterways, shading out more desirable aquatic flora, deoxygenating the water, and producing sulfide odors as they deteriorate. Millions of dollars are spent annually attempting to control these pests. Methods include mechanical removal, use of chemicals (usually 2,4-D), and, more recently, biological control agents. Although *Hydrilla* is present in the study area and represnets a serious threat, the most prevalent problems appear to be those caused by overabundances of water hycinth, which currently is controlled primarily by 2,4-D. Recent press releases, however, indicate a good potential for biological control of water hyacinth by a host-specific South American weevil. The U.S. Army Corps of Engineers reportedly is planning to introduce the weevils into the hyacinth-clogged portions of the Withlacootchee River immediately north of the study area.

Both mosquitos and midges are locally abundant; the plentiful lakes and wetlands provide extensive breeding habitat. Midges, which are more common than mosquitos, breed in streams as well as in most lentic habitats, whereas mosquitos breed only in standing water. Apparently, according to various county insect patrols, neither group is presently causing nuisance conditions in the study area. These insects, which generally incur nuisance conditions in the aerial adult stage, are discussed further in Volume VI, Section 5.

The potential or realized nuisance or pest fish species occurring in the fresh waters of the study area include four native species [gizzard shad, bowfin (mudfish), Florida spotted gar, and longnose gar] and 24 exotic species (Table 3.4). Of the native species, the gizzard shad, generally considered a forage fish, thrives in the moderate to highly eutrophic lakes and impoundments of Polk and Hillsborough counties and soon outgrows the size range useful to any but the largest predators (e.g., adult largemouth bass, striped and hybrid striped bass, gar, or large channel catfish). In its early life stages, this species generally outcompetes more desirable species (e.g., centrarchids) for food and, when relatively safe from predators, outcompetes for space; eventually, the desirable populations are eliminated, depleted, or severely stunted. This condition can be observed in a number of highly eutrophic lakes in Polk County, including Lakes Parker, Effie, Hancock, and Lulu (FGFWFC 1975).

Table 3.4. Distribution and Status of Exotic Fishes in Aquatic Habitats in Study Area

Species	Status
Tilapia nilotica	Established in lakes and ponds in Hillsborough County
Blue tilapia	Probably established in all habitat types throughout the study area
Cichlasoma trimaculata	Established in lakes and ponds in Manatee County
Climbing perch	Established in standing and running water natitats of Manatee County
Twospot climbing perch	Established in standing and running water habitats of Manatee County
Dwarf gourami	Questionable presence in Hillsborough County
Blue acara	Questionable presence in Hillsborough County
Rio Grande perch	Present in rivers and streams of Hillsborough County
Jack Dempsey	Established in canals and ditches of Hillsborough County
Jewelfish	Established in springs in Hillsborough County
Congo tilapia	Recently eradicated from lakes and ponds in Polk County
Blackchin tilapia	Established in lotic and estuarine habitat types in Hillsborough County
Mozambique tilapia	Established in lotic habitats in Hillsborough County
Walking catfish	Established in lotic habitats in Hillsborough County and reported to be present in the Peace River in DeSoto County
Armored catfish	Established in lotic and estuarine habitats of Hillsborough County
Swordtail molly	Established in Hillsborough County
Guppy	Established in Hillsborough County
Black molly	Established in Polk and Hillsborough counties
Southern platyfish	Established in Hillsborough County
Variable platyfish	Established in Hillsborough and Manatee counties
Green swordtail	Established in Polk, Hillsborough, and Manatee counties
Red sworitail	Established in Hillsborough County
Tilapia macrocephala	Established in lotic and estuarine habitats of Hillsborough County
Hoplias malabaricus	Established in lotic and estuarine habitats of Hillsborough County

The remaining three native species, although predators, are not among fishes desired for sport or food value. These species are occasionally sought, but most anglers and commercial fishermen consider them trash fish that take the bait meant for more desired fish. They also prey on the young and sometimes the adults of those species most highly prized by both fisheries.

The 24 presently known exotic fishes in the study area are but a relatively small proportion of the introduced fish species within Florida. Methods of introducing these exotics are numerous and currently uncontrolled. Neither existing laws nor industry controls are entirely capable of curtailing their flow. Generally, they are potentially uncontrolled agents of uncalculated environmental change, but the majority are relatively restricted in distribution in the study area. However, one species, the blue tilapia (*Tilapia aurea*), which has the widest distribution of any exotic fish species yet introduced in the state, has established breeding populations in all seven counties (Courtenay et al 1974). This herbivore, a native of West Africa, thrives, along with gizzard shad, in many of the moderately to highly eutrophic lakes, impoundments, and ponds of Hillsborough and Polk counties and in a number of river systems including the freshwater extent of the Peace River. Where blue tilapia are present in large numbers, streams are devoid of vegetation and consequently devoid of nearly all native fish that utilize vegetation (Courtenay and Robins 1973). Other than large predators, tilapia have few natural enemies, although fry and juveniles are probably forage for most predatory fishes. The angling value and catchability of this species in Florida waters is low since it is seldom taken on artificial or natural baits. Food value is relatively low at present, although like other *Tilapia* species, it is commercially exploited to a certain extent. In potentially weakened systems such as the eutrophic lakes of Polk County or the Peace River, which has sustained a number of major fish kills since 1960, an exotic like the blue tilapia can more easily displace native species in the existing trophic structure.

A number of exotic species listed in Table 3.4, including the seven molly species and the armored catfish are considered innocuous, apparently fitting unobtrusively into the existing communities.

SECTION 4

RESOURCE MANAGEMENT

A. AGENCIES AND PROGRAMS

A considerable number of federal, state, private and academic agencies and programs have been created to manage, regulate, preserve, and promote the abundant aquatic natural resources in Florida. Some of the more notable agencies and programs and their primary functions are discussed in the following paragraphs.

1. Division of Resource Management

The Environmental Reorganization Act of 1975 (Chapter 75-22, Laws of Florida) created the Division of Resource Management, which administers a number of programs offering outdoor recreation and has the potential to expand such activities. This division is charged with managing Florida's aquatic preserve system. At present, 31 aquatic preserves comprising more than 320,000 hectares (800,000 acres) have been established under the Florida Aquatic Preserve Act of 1975 (Section 258.35, Florida Statutes), which was instituted to insure that all state-owned submerged lands in areas having exceptional biological, aesthetic, and scientific value will be set permanently aside as preserves or sanctuaries for the benefit of future generations. Regulatory protection and preserve management emphasize protection of the existing natural values as well as the promotion of compatible outdoor recreation such as boating, fishing, skin diving, and nature appreciation. Aquatic preserves within the study area are mapped and discussed further in Volume VI, Section 5.

2. Game and Fresh Water Fish Commission

The Florida constitution (Article IV, Section 9) and Chapter 372, Florida Statutes, charges the Game and Fresh Water Fish Commission with exercising all the nonjudicial powers of the state with respect to wildlife and freshwater aquatic life. Presently, the commission manages 46 wildlife management and 56 fish management areas on state, federal, and privately owned lands; 13 of these are within the study area: six in Polk County; two in Hillsborough County; one each in Manatee, Hardee, and DeSoto counties and two in Charlotte County. As part of a statewide program, the commission's recreational improvements include developing and maintaining user-access areas, camping areas, and boat ramps. The commission's 56 fish management areas comprise more than 33,600 hectares (84,000 acres) of public water. Recreational enhancement of these waters includes establishing and maintaining boat ramps, fish stocking and management, installing fish attactors, and performing aquatic weed control. In addition to state monies, the Game and Fresh Water Fish Commission receives federal funds from the Pittman-Robertson and Dingell-Johnson programs.

a. Pittman-Robertson Federal Aid Program

This program derives revenue from federal taxes on arms and ammunition sales and uses the monies for programs designed to restore and preserve wildlife, especially game and nongame birds and animals. In the past, the Florida Game and Fresh Water Fish Commission has used funds from this program to acquire and manage wildlife management areas and leasing programs.

b. Dingell-Johnson Federal Aid Program

Created by the Federal Aid in Fish Restoration Act of 1950, this program collects funds through federal taxes on fishing tackle and equipment sales and makes these monies available to participating states based on the number fo licenses sold in that state. The monies are designed specifically to promote and utilize sport fisheries management. Typical programs within the study area are lake and stream surveys (especially in Polk County), fish studies, lade management studies, boat-ramp construction, basin studies, and disease studies.

3. Division of Forestry

Operating under Chapter 589, Florida Statutes, the Division of Forestry promotes recreational enjoyment by providing programs and facilities in state forest areas. Florida's state forest system, which consists of four forest areas totalling 122,400 hectares (306,000 acres), provides outdoor recreational activities such as hunting, fishing, camping, picnicing, and nature study.

4. Department of Environmental Regulation

This department was established by Florida's Environmental Reorganization Act of 1975 to perform two basic functions pertinent to wildlife and fish management areas: issue environmental permits that require all recreational development activities affecting air and water quality to meet state standards; and enforce the permitting regulations.

5. U.S. Fish and Wildlife Service

Through U.S. Fish and Wildlife Service, visitors to 23 wildlife areas in Florida (comprising 176,200 hectares, or 438,000 acres) are provided high-quality, safe, enjoyable recreational experiences oriented toward wildlife and wildlife habitats. Activities include hunting, fishing, wildlife observation, and photography.

6. National Marine Fisheries Service, NOAA, Gulf Coastal Fisheries Center

The Panama City Laboratory, originally established in 1966 by the Bureau of Sport Fisheries and Wildlife, U.S. Department of the Interior, has been transferred to the National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce. Research conducted under the auspices of the Panama City Laboratory involves marine recreational fisheries, biology of marine fishes, and coastal and estuarine ecology of the Gulf of Mexico.

7. Florida Sea Grant Marine Advisory Program

The Florida Sea Grant Marine Advisory Program, through the Florida Cooperative Extension Service, serves all the state's costal counties. Multi-county agents serve specific geographic areas, and campus-based specialists are available to users throughout the state. A periodic newsletter, advisory bulletins, and scientific reports are published as contributions to the applied development of coastal and marine resources.

8. Gulf Breeze Environmental Research Laboratory, U.S. Environmental Protection Agency

The Gulf Breeze Environmental Research Laboratory near Pensacola plans, conducts, and manages research on the ecological effects of biological and synthetic pesticides, other synthetic hazardous organics, and chlorine on the marine environment. Specific responsibiilites include the development of information essential for the pesticide registration and control program that provides supporting data for the development of water-quality criteria to protect aquatic life in marine and estuarine environments.

9. Bureau of Marine Sciences and Technology, Florida Department of Natural Resources

More than 65 marine biologists, technicians, and support personnel provide biological knowledge supporting marine resource legislation and serve in advisory capacity in implementing such management policies and regulations. Personnel work in four major areas: descriptive biology, fisheries biology, ecological studies, and mariculture/pathology research and development.

B. AQUATIC FLORA

There are currently two basic forms of aquatic flora management in the study area: control of noxious aquatic plants and algae and reestablishment of desirable shore grasses and aquatic macrophytes to promote the development of good fish and invertebrate communities. Through geologic aging, greatly accelerated by man's activity, many of the larger and heavily used lakes in Polk and Hillsborough counties are becoming highly eutrophic. Eutrophic lakes, as indicated in the discussion of nuisance and pest species, are characterized by dense blooms of phytoplankton and/or luxuriant growth of algae and aquatic macrophytes. Highly eutroplic lakes in Polk County include Parker, Banana, Effie, Hancock, and Lulu.

Tactics used to control eutrophic conditions have involved water drawdown and dredging of the organically-laden bottom substrate, spraying with herbicides including diquat and 2,4-D, mechanically harvesting the algae and weeds, and introducing biological control agents such as tilapia or the white amur. However, these short-term control measures have created two major problems:

- Uncontrolled killing of noxious aquatic weeds (e.g. water hycinth, hydrilla) generally causes these plants to sink to the bottom of the affected water body, allowing rapid recirculation of nutrients into the water column and creating anerobic conditions and a build-up of organic silt. Each time the plants are sprayed, the increased available nutrients can be utilized in other undesirable forms such as algae blooms.

- Introduction of exotic fishes for weed control without sufficient consideration of ecological damage to the native freshwater aquatic habitat has resulted in the imbalance and deterioration of the freshwater fisheries in a number of lakes, ponds, canals, and ditches within the study area, including the aforementioned lakes. In the majority of cases, the introduced species has competed with and/or replaced to a large extent desireable native freshwater species.

A series of suggested long-term implementations for controlling and managing unwanted aquatic flora include:

- The drawdown of highly eutrophic lakes, coupled with the addition of a new water source (possibly well or diverted streamflow)
- Implementation of more efficient nutrient removal from industrial, domestic, and agricultural effluents.
- Stricter legislation to reduce and control herbicides used in the environment
- Development of a mechanical aquatic weed harvester that can transform aquatic weeds into animal food supplements
- Investigation of various organisms, native and exotic, that are capable of biologically controlling problem aquatic plants without interfering with balance in community structure

In addition to plant removal, management of aquatic flora also involves the transfer and transplanting of shorezone grasses as well as aquatic macrophytes. To establish vegetation at the new Lake Juliana Fish Management Area in Polk County, for example bulrush from nearby Lake Hunter and waterlily from Lake Gibson were transplanted, and transplanting emergent grasses was contemplated. Such practices, when implemented, create a shorezone vegetation buffer which will prevent or slow erosion of the shoreline, provide cover and habitat for fishes and aquatic invertebrates, and create an aesthetically attractive landscape.

C. MACROINVERTEBRATES

The Florida Game and Fresh Water Fish Commission has established and regulates creel (or bag) limits on the taking of freshwater crayfish, conch, and blue and stone crabs within the state's streams, rivers, bays, estuaries, and coastal waters. The Division of Marine Resources, in conjunction with local coastal public health officials, controls the commercial and recreational shellfishing grounds within the state's coastal borders. A number of research programs funded by commercial and private institutions as well as the Florida Department of Natural Resources are examining aquaculture and mariculture techniques for a variety of macroinvertebrates including fresh and estuarine shrimp, clams, and oysters. Also under investigation are the development and rehabilitation of oyster reefs previously closed to commercial and recreational harvest and those overfished during past years.

D. FISHES

1. Freshwater

The freshwater fisheries within the study area comprise three major categories based on the environmental conditions of the water body:

- Water bodies with little or no sport fishery and with dense shad and tilapia populations. These are lakes and impoundments or streams with extremely degraded and/or eutrophic environments. Lakes Parker, Banana, Effie, Hancock, and Lulu fall within this category.

- Water bodies with good sport fisheries potentially threatened by coarse fish populations. These include water bodies with lesser amounts of environmental deterioration. Within this category are Lakes Bonny, Hollingsworth, Shipp, Henry, Cannon, Corine, Eloise, Howard, Idlewild, and Roy in Polk County and Lake Thonotosassa and East Lake in Hillsborough County.

- Water bodies with a viable sport fishery and good water quality. These water bodies are in a relatively early stage of eutrophication. Lakes in Polk County meeting these criteria include Reedy, Hunter, Gibson, and Walk-n-Water.

In the past, many lakes and running waters supported self-perpetrating sport fish populations that met the needs of the fishing public. However, recent drastic changes in many lake environments, mostly through man-made perturbations, have created undesirable changes in community structure. The management techniques utilized to renovate and reclaim as well as preserve and maintain present and potential fisheries resources are many and varied and are generally tailored to accommodate local environments.

Although the management practice of supplemental stocking was once considered of slight value because of economically unfeasible techniques or abundant sport fishery resources in alternative water bodies, it is now being examined and utilized to restore certain previously utilized and degraded aquatic environments. Desirable native and exotic fishes such as the snook, striped and hybrid striped bass, and white amur, which exhibit superior short-term qualities and can live in adverse aquatic environments where most natural populations of sport fish such as largemouth bass cannot live or successfully reproduce, are being investigated and selectively reared and stocked in specific, carefully controlled areas. Supplemental stocking of sport fishes including largemouth bass, redear and bluegill sunfish, black crappie, and channel catfish in the lotic and lentic waters of the study area has compensated for these species' reduced natural production. This type of program helps maintain the sport fish populations in heavily fished areas, reduce forage species levels, and recolonize water bodies following renovation procedures of fish kills. Additional stocking of nonindigenous fishes such as sunshine and striped bass may aid supplemental largemouth bass stocking.

Fish attractors to increase the harvest of game fish have been installed in a number of Polk County lakes including Wire, Agnes, Juliana, Helene, Starr, and Crooked. These attractors utilize a variety of materials to attract small forage fishes, provide hiding places for large predators, and support catfish reproduction and are apparently effective for sunfish species, channel and white catfish, and shiners.

As part of its overall management plan, the Florida Game and Fresh Water Fish Commission also controls the taking of fish. For example it established and promotes fishing for commercial trash and coarse fishes in order to reduce the forage and stunted panfish populations. This decreases competition for food and habitat and assists the recovery of sport fish populations to desirable sizes and ratios. The operation includes strict licensing procedures, gear and harvest regulations, catch record and inspection fee requirements, and controlled disposition of the catch. The commission also maintains a fisherman licensing program that, in part, sets legal bag limits on a number of game and freshwater sport fishes; these limits, enforceable by fines, apply to certain fish in all public, state, and federal fresh waters.

A major influence in the commission's management plans is the view that sport fishing, especially bass fishing, has increased at a time when many bass fisheries are rapidly deteriorating and that this unprecedented fisherman utilization dictates that all potentially productive waters be used for bass fisheries (FGFWFC 1975). The use of reclaimed and unreclaimed phosphate mining areas for fishing and recreation is proposed to meet the urgent needs of the over-expanding Florida population for outdoor recreation facilities (W.R. Grace 1975). The Division of Parks and Recreation, however, has pointed out the relatively low use-demand statistics for 1975 through 1990 for freshwater fishing. The division concludes that, although Florida abounds in well-stocked lakes and streams, tourists prefer saltwater to freshwater fishing and that Florida has no need for additional freshwater fishing areas because of the almost limitless availability of Atlantic and Gulf waters and the present availability of thousands of lakes and streams (Florida Division of Recreation and Parks 1976).

2. Estuarine/Marine

Management techniques currently used in the estuarine waters of the study area include:

- Bag and creel limits on a number of estuarine sport and games fishes, as well as minimum size limits
- Scrutiny and environmental evaluation of any requests from local developers or municipalities for construction, dredging, filling, and bulkheading permits for estuarine or coastal areas involving tracts below the mean high water line
- Licensing of commercial fishermen and requirements for reporting catch statistics by poundage for selected species and species groups
- Mariculture of selected valuable sport and commercial fish species for potential inclusion in the commercial harvest
- Assessment and regulation of industrial and domestic users of estuarine and/or coastal waters for cooling, development, or effluent purposes
- Creation of inshore and offshore artificial reef habitats to attract certain species and thereby enhance the sport and commercial fisheries of Florida's coastal counties
- Use of population surveys, ecological and inventory surveys, sport and commercial fishery statistics, evaluations of fishery-associated industries, and environmental impact assesments to evaluate, regulate, and manage more fully the estuarine-dependent fisheries resources along Florida's western Gulf Coast

SECTION 5

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APPENDIX 1

STREAM SEGMENTS AND SAMPLING STATIONS

APPENDIX 1

STREAM SEGMENTS AND SAMPLING STATIONS

The following were the stream segments (Plate 1 in pocket) used to characterize the study area's water quality:

P.1	Saddle Creek from headwaters to SR 555 bridge
P.2	Peace Creek drainage canal from headwaters to confluence with Peace River
P.3	Peace River from SR 555 bridge to confluence with Sixmile Creek at Clear Springs
P.4	Peace River from confluence with Sixmile Creek to SR 657 bridge
P.5	McCullough Creek and Whidden Creek from headwaters to confluence with Peace River
P.6	Bowlegs Creek from headwaters to confluence with Peace River
P.7	Peace River from SR 657 bridge to confluence with Little Payne Creek
P.8	Little Payne Creek from headwaters to confluence with Peace River
P.9	Peace River from confluence with Little Payne Creek to DeSoto County line
P.10	Charlie Creek from headwaters to confluence with Peace River
P.11	Peace River from DeSoto County line to SR 70 bridge
P.12	Peace River from SR 70 bridge to SR 760 bridge
P.13	Joshua Creek from headwaters to confluence with Peace River
P.14	Peace River from SR 760 bridge to Interstate 41 bridge
A.1	Poley Creek from headwaters to confluence with North Prong of Alafia River
A.2	North Prong of Alafia River from headwaters to S.C.L. RR crossing east of Nichols
A.3	North Prong of Alafia River from S.C.L. RR crossing east of Nichols to confluence with Thirtymile Creek
A.4	Thirtymile Creek from headwaters to confluence with North Prong of Alafia River
A.5	English Creek from headwaters to confluence with North Prong of Alafia River
A.6	North Prong of Alafia River from confluence with Thirtymile Creek to SR 676 bridge

A.7	North Prong of Alafia River from SR 676 bridge to confluence with Alafia River
A.8	South Prong of Alafia River from headwaters to Hurrah Lake
A.9	South Prong of Alafia River from Hurrah Lake to confluence with Alafia River
A.10	Alafia River from confluence with North and South Prongs of Alafia River to confluence with Little Fishawk Creek
A.11	Alafia River from confluence with Little Fishawk Creek to confluence with Buckhorn Creek
A.12	Alafia River from confluence with Buckhorn Creek to mouth of Alafia River
H.1	Hillsborough River from Hillsborough County line to confluence with Flint Creek
H.2	Hillsborough River from confluence with Flint Creek to SR 582 bridge
H.3	Hillsborough River from SR 582 bridge to SR 685 bridge
H.4	Hillsborough River from SR 685 bridge to mouth of Hillsborough River
LM.1	Little Manatee River from headwaters to confluence with south fork of Little Manatee River
LM.2	South fork of Little Manatee River from headwaters to confluence with Little Manatee River
LM.3	Little Manatee River from confluence with south fork of Little Manatee River to Interstate 301 bridge
LM.4	Little Manatee River from Interstate 301 bridge to mouth of Little Manatee River
M.1	Manatee River from headwaters of north and east forks to confluence with Fisher branch
M.2	Manatee River from confluence with Fisher branch to Rye Bridge Road
M.3	Manatee River from Rye Bridge Road to mouth of Manatee River
MY.1	Myakka River from headwaters to SR 70 crossing
MY.2	Myakka River from SR 70 crossing to Jackson Road crossing north of Manhatten farms
MY.3	Myakka River from Jackson Road crossing north of Manhatten farms to confluence with Deer Prairie Creek
MY.4	Myakka River from confluence with Deer Prairie Creek to Charlotte County line
MY.5	Myakka River from Charlotte County line to SR 771 bridge
BS.1	Big Slough from headwaters to confluence with drainage ditch in North Port 4.42 kilometers (2.75 miles) northeast of Interstate 41 bridge

BS.2	Big Slough from confluence with drainage ditch in North Port 4.42 kilometers (2.75 miles) northeast of Interstate 41 bridge to confluence with Myakka River
HC.1	Horse Creek from headwaters to SR 64 bridge
HC.2	Horse Creek from SR 64 bridge to DeSoto County line
HC.3	Horse Creek from DeSoto County line to SR 761 bridge
HC 4	Horse Creek from SR 761 bridge to confluence with Peace River
S.1	Prairie Creek and Myrtle Slough from headwaters to SR 31 bridges
S.2	Prairie Creek and Shell Creek from SR 31 bridges to SR 764 bridges
S.3	Prairie Creek and Shell Creek from SR 764 bridges to mouth of Shell Creek
TB.1	Hillsborough Bay north of latitude 27°50'00"
TB.2	Old Tampa Bay north of latitude 27°50'00"
TB.3	Tampa Bay south of latitude 27°50'00"
CH.1	Charlotte Harbor north of latitude 26°52'00" and east of longitude 82°09'00"
CH.2	Charlotte Harbor north of latitude 26°52'00" and west of longitude 82°09'00"
CH.3	Charlotte Harbor south of latitude 26°52'00"

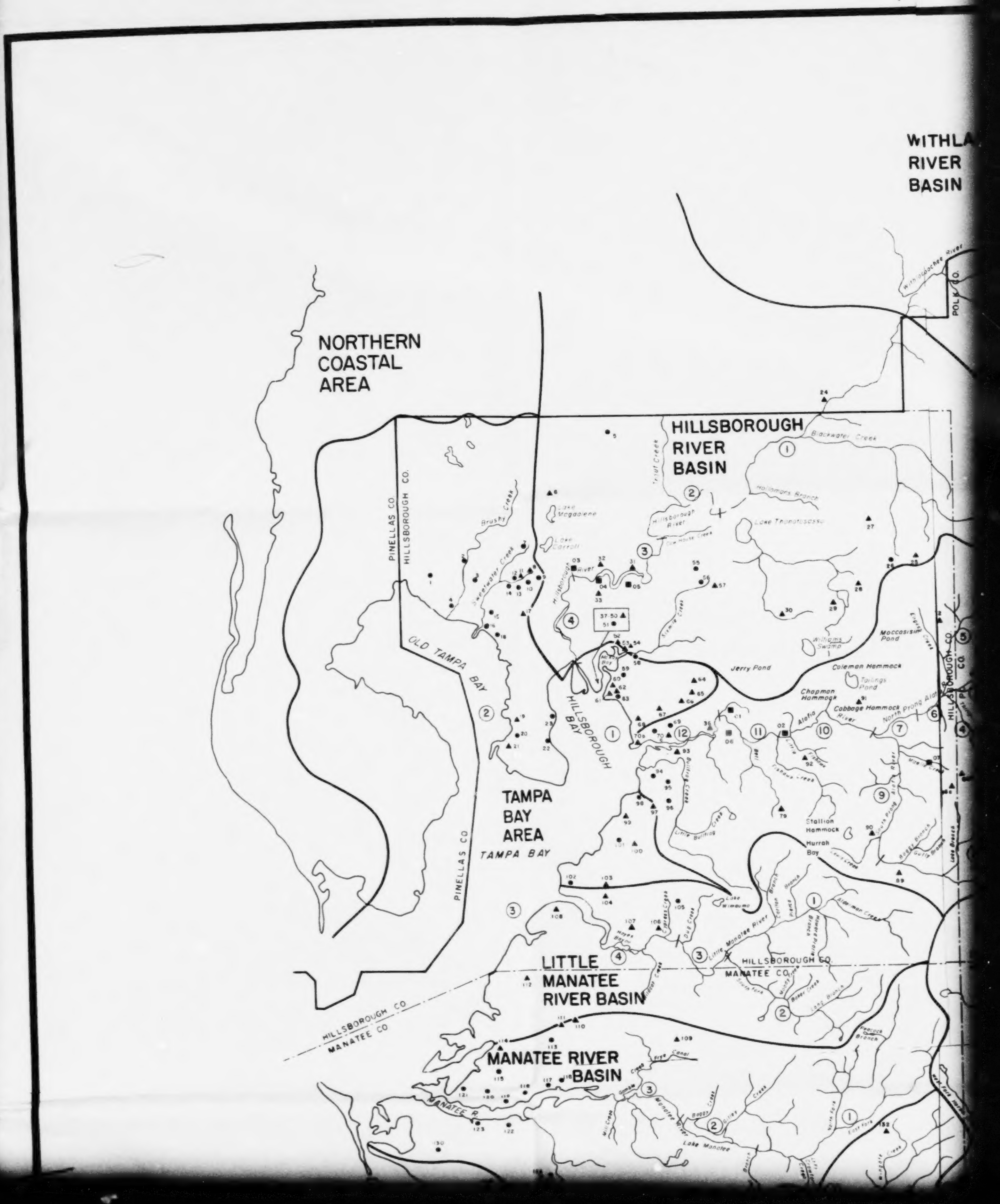
The following were the Florida Department of Environmental Regulation (FDER) and United States Geological Survey (USGS) sampling stations used to provide water quality data for each of the above stream segments:

P.1	USGS	02294491
	FDER	25020001, 25020056
P.2	USGS	02293986
	FDER	25020047
P.3	USGS	02294650
	FDER	25020037
P.4	USGS	02294898
	FDER	25020017
P.5	FDER	25020009, 25020092, 25020094
P.6	FDER	25020013
P.7	FDER	25020008, 25020012, 25021722
P.8	FDER	25020007
P.9	USGS	02295637
	FDER	25020006, 25020091
P.10	USGS	02296500

P.11	USGS	02296750
	FDER	25020004
P.12	FDER	25020003
P.13	USGS	271601081433200, 02297100
P.14	FDER	25020002
A.1	USGS	02300930
	FDER	24020061
A.2	USGS	02300852
	FDER	24020012, 24020013, 24020026
A.3	USGS	02300882
	FDER	24020035
A.4	FDER	24020031
A.5	USGS	02300978
	FDER	24020030, 24020305
A.6	USGS	02301000
A.7	USGS	02301350
	FDER	24020008, 24020028
A.8	FDER	24020021, 24020022
A.9	USGS	02301300, 02301314
	FDER	24020070
A.10	USGS	02301370, 02301500
	FDER	24020004, 24020034
A.11	USGS	02301697
	FDER	24020044
A.12	FDER	24020001, 24020002, 24020003
H.1	USGS	02302500, 02303100, 02303200, 02303350
	FDER	24030004, 24030130, 24030131, 24030135
H.2	USGS	02303271, 02303300, 02303320, 02303990
H.3	USGS	02304000
H.4	USGS	02304000, 02304500, 02304510, 280047082152500, 280150082111400
	FDER	24030011
LM.1	USGS	02300100
LM.2	USGS	02300200, 02300300
LM.3	USGS	02300500, 24010100
LM.4	USGS	02303800, 274214082265800
	FDER	24010103
M.1	USGS	02299950
M.2	USGS	272935082212000
	FDER	24010360, 24010361, 24010362, 24010363, 24010364, 24010365 24010366, 24010367

M.3	USGS	273018082342000
	FDER	24010346
MY.1	USGS	02298482
	FDER	25030009, 25030012, 25030100
MY.2	USGS	02298830
MY.3	FDER	25030403, 25030408
MY.4	FDER	25030402
MY.5	FDER	25030401
BS.1	FDER	25030021
BS.2	USGS	02299470
HC.1	FDER	25020428
HC.2	FDER	25020427, 25020430
HC.3	USGS	02297310
	FDER	25020111, 25020422, 25020423, 25020425
HC.4	FDER	25020422
S.1	USGS	270332081461400, 271231081404200, 271232081343300
	FDER	25020434
S.2	USGS	02298123
	FDER	25020124, 25020435
S.3	USGS	02298202
	FDER	25020431, 25020432, 25020433
TB.1	USGS	02301761, 02306100
	FDER	24030702, 24030703
TB.2	USGS	02300072, 275435082341600, 275653082361900, 2758400823736000
	FDER	24040231, 24040251
TB.3	USGS	02300085, 02300088, 02300560, 02308426, 273858082366 4800, 274405082315000, 274744082291000
	FDER	24010190, 24010293, 24010294, 24010295, 24010296, 24010297, 24010298, 24020904, 24040371, 24040391
CH.1	(USGS 120015 [Finger Fill Canal Study])	
	FDER	25010001, 25010003, 25010006, 25010012, 25020488, 25020489, 25020491
CH.2	FDER	25010010
CH.3	(USGS 120015-D [Finger Fill Canal Study])	
	FDER	25010004, 25010005

*U.S. GOVERNMENT PRINTING OFFICE: 1978-640-922/6193. Region 4.


WITHLA
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Withlacoochee River
POLK CO.
NORTHERN
COASTAL
AREA
HILLSBOROUGH
RIVER
BASIN
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Trout Creek
Hollomans Branch
Hillsborough River
Cow House Creek
Lake Thonotosassa
Lake Magdalene
Lake Carroll
Brushy Creek
Sweetwater Creek
PINELLAS CO.
HILLSBOROUGH CO.
OLD TAMPA BAY
HILLSBOROUGH BAY
McKay Bay
Sixmile Creek
Williams Swamp
Jerry Pond
Moccasin Pond
Coleman Hammock
Tailings Pond
Chapman Hammock
Cabbage Hammock
North Prong Alafia River
Alafia River
Fishhawk Creek
Turkey Creek
Bullfrog Creek
Little Bullfrog Creek
Stallion Hammock
Murrah Bay
South Prong Alafia River
Boggy Branch
Lake Branch
TAMPA
BAY
AREA
TAMPA BAY
PINELLAS CO.
Lake Wimauma
Cypress Creek
Curiosity Creek
Carlton Branch
Pierce Branch
Alderman Creek
Little Manatee River
Hayes Bayou
Howard Prairie Branch
LITTLE
MANATEE
RIVER BASIN
HILLSBOROUGH CO.
MANATEE CO.
South Fork
Boker Creek
Long Branch
Peacock Branch
HILLSBOROUGH CO.
MANATEE CO.
MANATEE RIVER
BASIN
Gamble Creek
Frye Canal
MANATEE R.
Mill Creek
Manatee River
Boggy Creek
Gilley Creek
Lake Manatee
North Fork
East Fork
Wingate Creek
HILLSBOROUGH CO.
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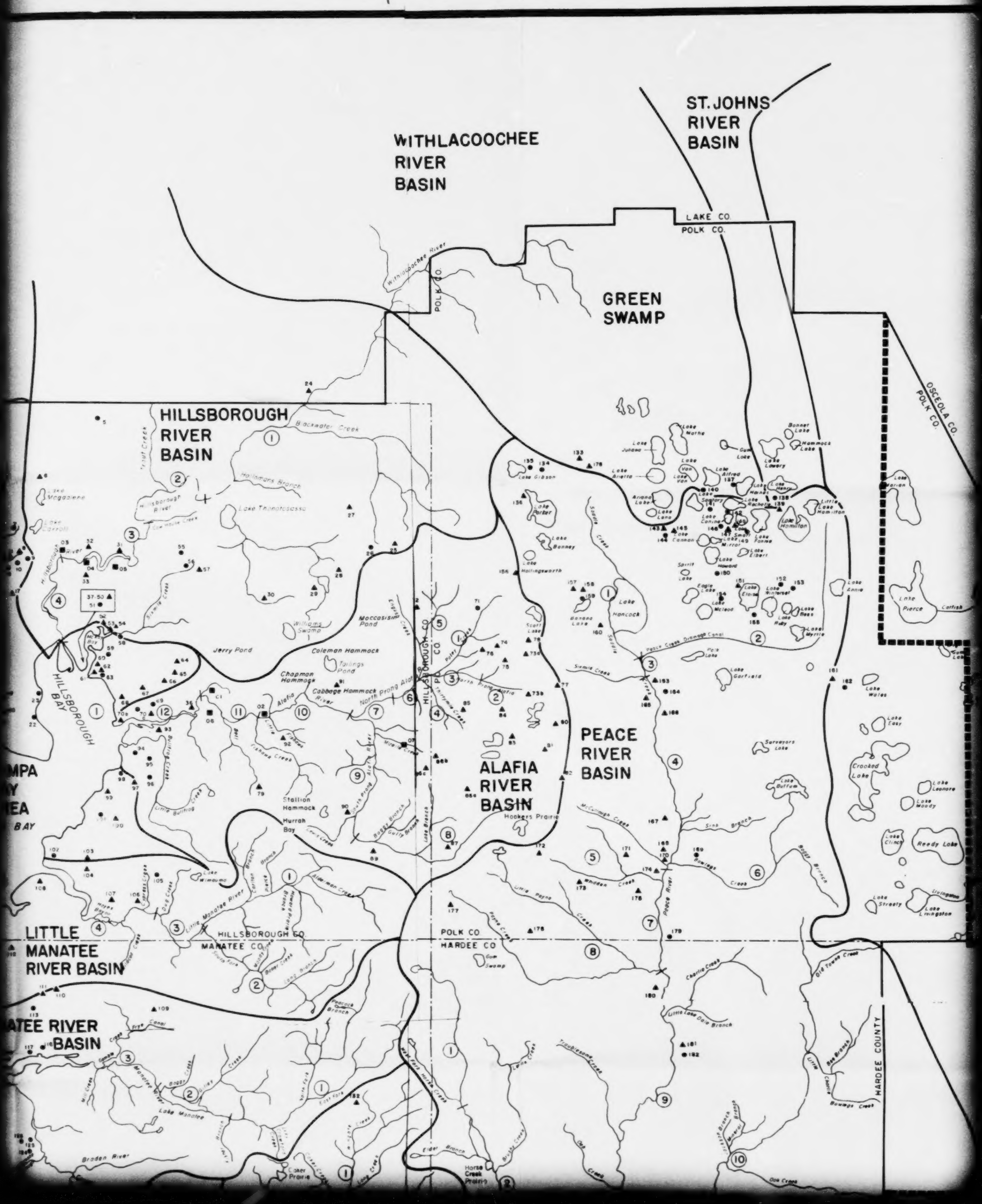
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ST. JOHNS RIVER BASIN
LAKE CO.
POLK CO.
GREEN SWAMP
Withlacoochee River
OSCEOLA CO.
POLK CO.
HILLSBOROUGH RIVER BASIN
Blackwater Creek
Hollomans Branch
Lake Thonotosassa
Hillsborough River
Cow House Creek
Lake Magdalene
Lake Carroll
Sixmile Creek
Williams Swamp
Moccasin Pond
Jerry Pond
Coleman Hammock
Tailings Pond
Chapman Hammock
Cabbage Hammock
North Prong Alafia River
South Prong Alafia River
Alafia River
Fishhawk Creek
Bullfrog Creek
Little Bullfrog Creek
HILLSBOROUGH BAY
HILLSBOROUGH CO.
POLK CO.
Stallion Hammock
Hurrah Bay
ALAFIA RIVER BASIN
Hookers Prairie
PEACE RIVER BASIN
Peace Creek Drainage Canal
Saddle Creek
Lake Parker
Lake Gibson
Lake Hancock
Lake Bonney
Lake Hollingsworth
Banana Lake
Scott Lake
Lake Hamilton
Lake Juliana
Lake Mattie
Lake Arietta
Lake Alfred
Lake Haines
Lake Rochelle
Lake Conine
Lake Howard
Lake Eloise
Lake Shipp
Lake Mirror
Lake Cannon
Lake Elbert
Eagle Lake
Lake McLeod
Spirit Lake
Lake Winterset
Lake Ruby
Lake Myrtle
Lake Annie
Lake Pierce
Lake Marion
Bonnet Lake
Hammock Lake
Lake Lowery
Gum Lake
Polk Lake
Lake Garfield
Lake Wales
Lake Easy
Surveyors Lake
Crooked Lake
Lake Buffum
Lake Leonore
Lake Moody
Lake Clinch
Reedy Lake
Lake Streety
Lake Livingston
Livingston
Catfish
McCullough Creek
Sink Branch
Bowlegs Creek
Whidden Creek
Little Payne Creek
Payne Creek
Peace River
Sixmile Creek
Charlie Creek
Little Lake Dale Branch
Old Town Creek
Little Charlie Bowlegs Creek
Troublesome Creek
Lettis Creek
Oak Creek
Elder Branch
Horse Creek Prairie
Brushy Creek
West Fork Horse Creek
HARDEE COUNTY
POLK CO.
HARDEE CO.
Gum Swamp
HILLSBOROUGH CO.
MANATEE CO.
LITTLE MANATEE RIVER BASIN
Little Manatee River
Alderman Creek
Carlton Branch
Dug Creek
Cypress Creek
Lake Wimauma
Howard Prairie Branch
South Fork
Long Branch
Bear Creek
Peacock Branch
Frye Canal
MANATEE RIVER BASIN
Manatee River
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Lake Manatee
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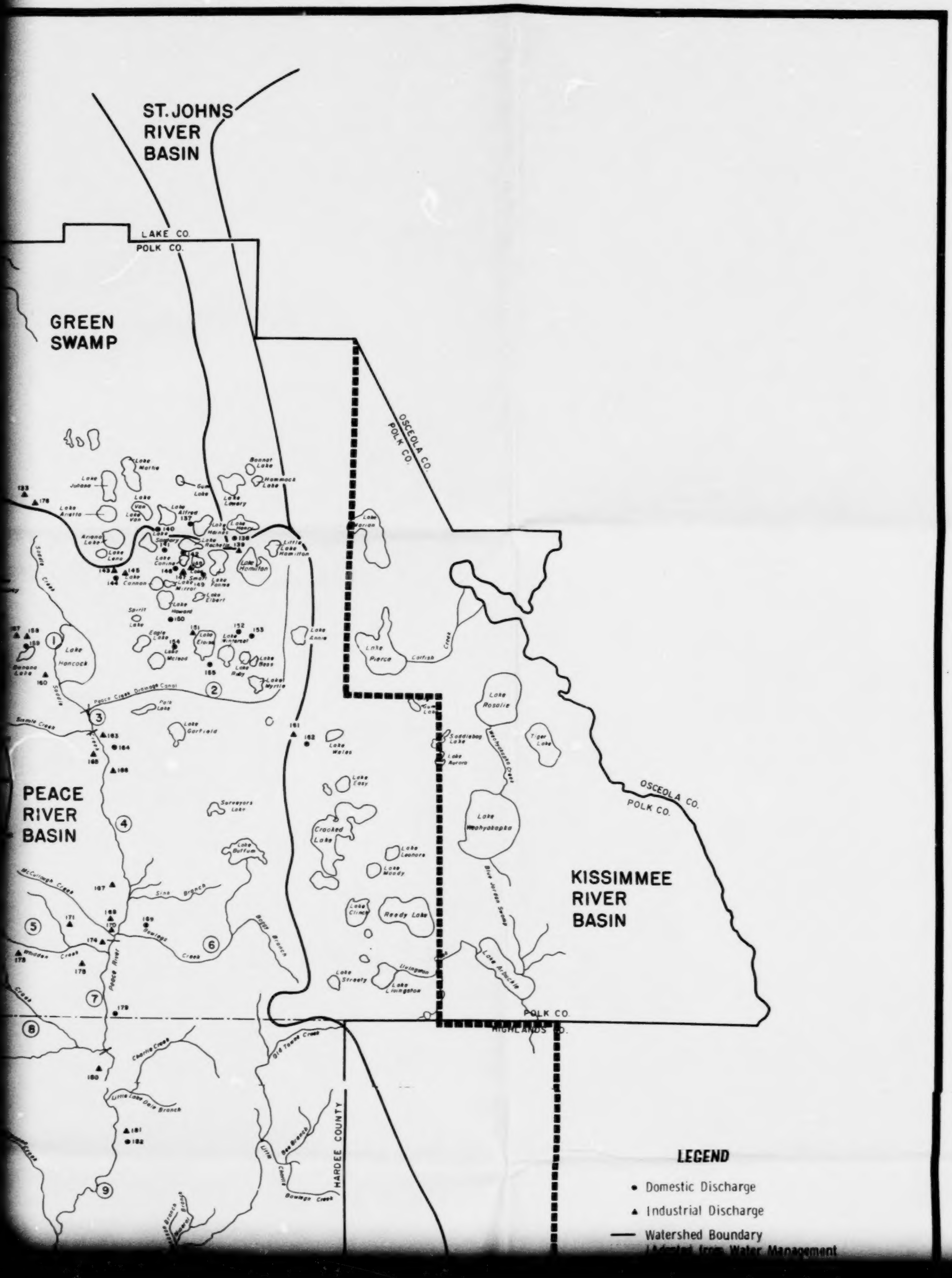
Mill Creek
Gilley Creek
Boggy Creek
North Fork
East Fork
Coker Prairie
TAMPA BAY AREA
BAY


ST. JOHNS RIVER BASIN
GREEN SWAMP
PEACE RIVER BASIN
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LAKE CO.
POLK CO.
OSCEOLA CO.
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POLK CO.
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HIGHLANDS CO.
HARDEE COUNTY
Lake Mattie
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Hammock Lake
Gum Lake
Lake Lowery
Lake Arietta
Lake Van
Lake Alfred
Lake Haines
Lake Henry
Arianna Lake
Lake Saddlery
Lake Rochelle
Little Lake Hamilton
Lake Lena
Lake Conine
Lake Hamilton
Lake Cannon
Lake Mirror
Small Lake
Lake Fannie
Lake Elbert
Lake Howard
Spirit Lake
Eagle Lake
Lake Eloise
Lake Winterset
Lake Annie
Lake Hancock
Banana Lake
Lake McLeod
Lake Ruby
Lake Bass
Lake Myrtle
Peace Creek Drainage Canal
Saddle Creek
Polk Lake
Lake Garfield
Lake Wales
Lake Pierce
Catfish Creek
Lake Marion
Gum Lake
Saddlebag Lake
Lake Aurora
Lake Rosalie
Tiger Lake
Weohyakapka Creek
Lake Weohyakapka
Blue Jordan Swamp
Lake Arbuckle
Lake Easy
Surveyors Lake
Crooked Lake
Lake Buffum
Lake Leonore
Lake Moody
Lake Clinch
Reedy Lake
Lake Streety
Livingston
Lake Livingston
Bonnie Creek
McCullough Creek
Sink Branch
Bowlegs Creek
Bear Branch
Whidden Creek
Peace River
Charlie Creek
Old Town Creek
Little Lake Dale Branch
Little Charlie
Bee Branch
Bowlegs Creek
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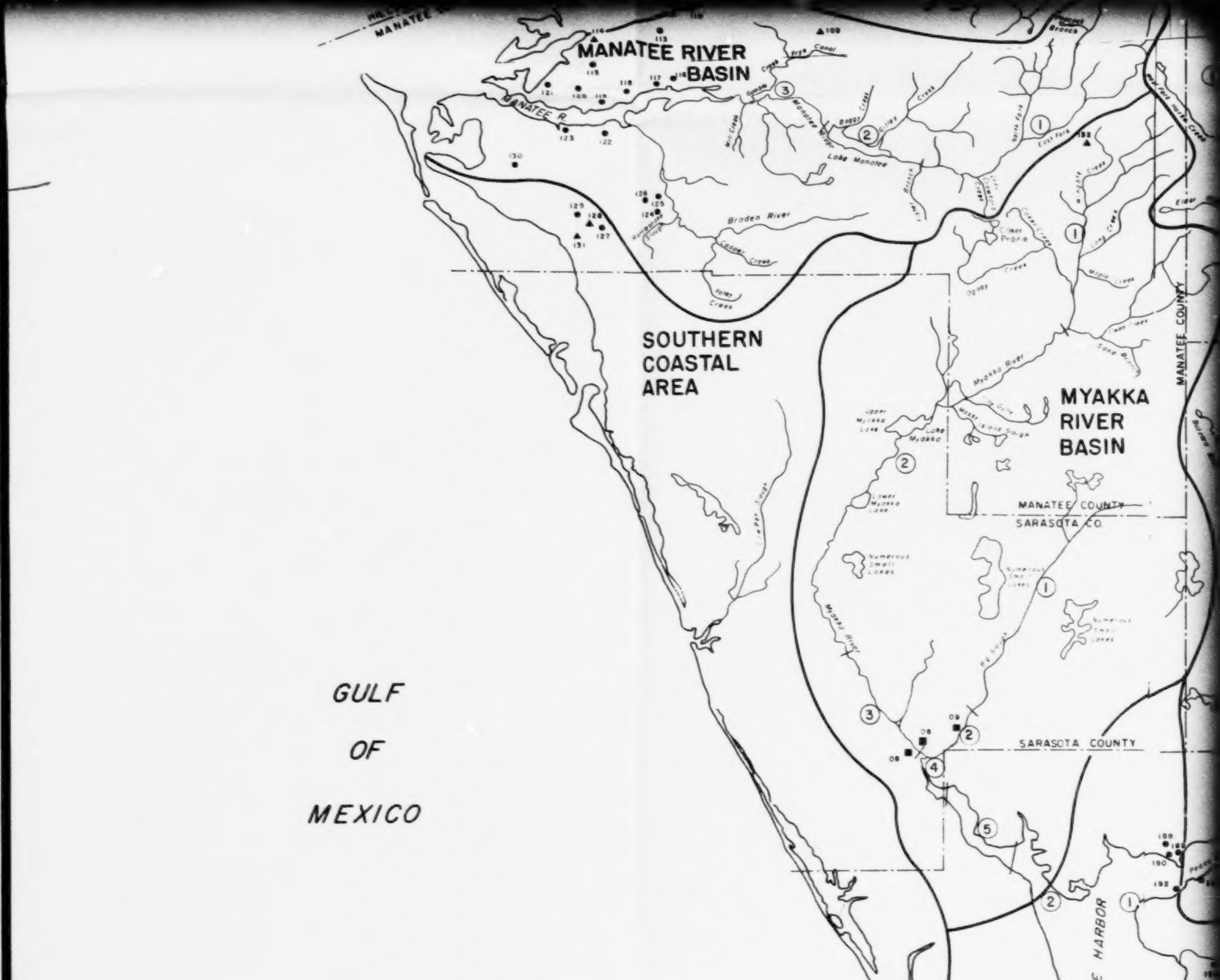
LEGEND
● Domestic Discharge
▲ Industrial Discharge
Watershed Boundary
(Adapted from Water Management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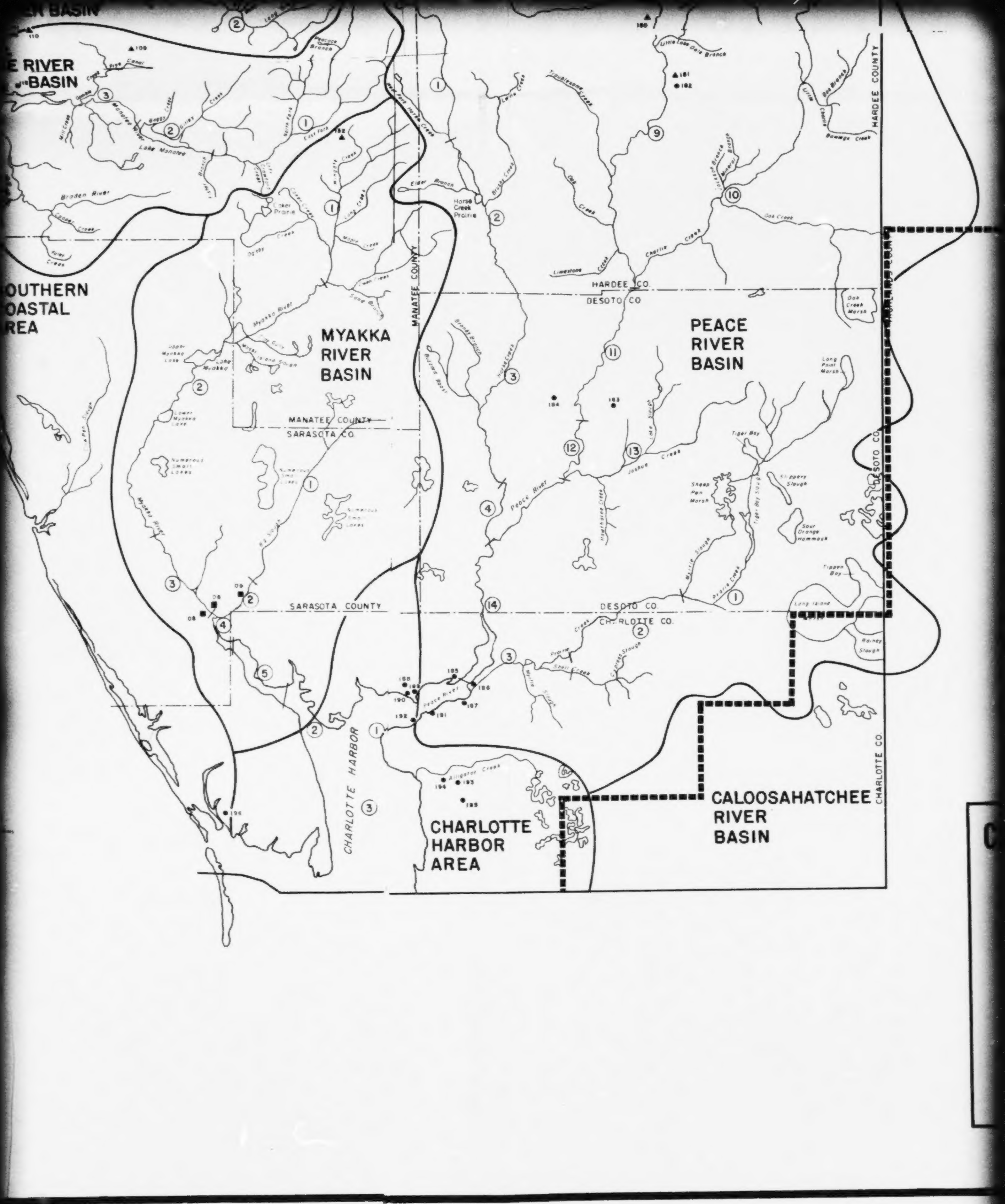
MANATEE R.
Lake Manatee
Braden River
SOUTHERN COASTAL AREA
MYAKKA RIVER BASIN
Myakka River
Upper Myakka Lake
Lake Myakka
Lower Myakka Lake
Numerous Small Lakes
MANATEE COUNTY
SARASOTA CO.
SARASOTA COUNTY
CHARLOTTE HARBOR
GULF OF MEXICO
SCALE 1:250,000
N
LOCATION OF STUDY AREA WITHIN FLORIDA

Source: Geraghty & Miller, Inc., 1977, Corps of Engineers, Water Resources Management Study, Hydrologic and Engineering Evaluation of the Four River Basins Area-Central Florida, and Texas Instruments Inc., as described in text.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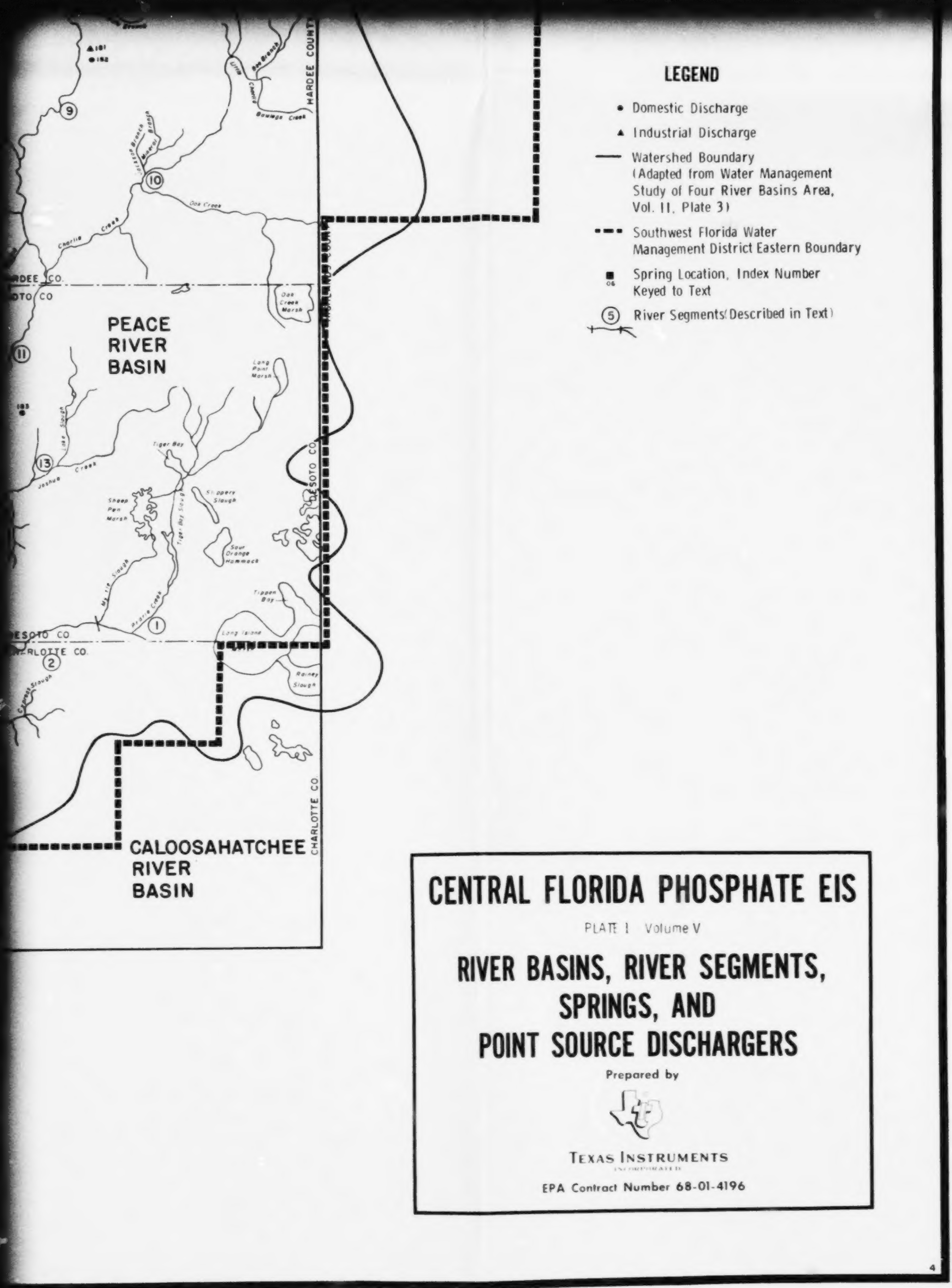
PEACE RIVER BASIN
CHARLOTTE HARBOR AREA
CALOOSAHATCHEE RIVER BASIN
SOUTHERN COASTAL AREA
RIVER BASIN
MANATEE COUNTY
SARASOTA CO.
SARASOTA COUNTY
HARDEE CO.
DESOTO CO.
CHARLOTTE CO.
HARDEE COUNTY
CHARLOTTE HARBOR
Myakka River
Peace River
Manatee River
Lake Manatee
Braden River
Horse Creek
Horse Creek Prairie
Coker Prairie
Upper Myakka Lake
Lower Myakka Lake
Numerous Small Lakes
Charlie Creek
Oak Creek
Troublesome Creek
Limestone Creek
Joshua Creek
Shell Creek
Prairie Creek
Alligator Creek
Oak Creek Marsh
Long Point Marsh
Tiger Bay
Sheep Pen Marsh
Slippery Slough
Sour Orange Hammock
Tippen Bay
Long Island
Rainey Slough
Myrtle Slough
Cypress Slough
Hawthorne Creek
Lake Slough
Elder Branch
Bowlegs Creek
Little Lake Dale Branch
Peacock Branch
East Fork
North Fork
Gilley Creek
Mill Creek
Owen Creek
Big Slough
Buzzard Roost
Brandy Branch
Wingate Creek
Maple Creek
Sand Branch


▲181
●182
9
Little Charlie
Bee Branch
Bowlegs Creek
HARDEE COUNTY
Jackson Branch
10
Oak Creek
Charlie Creek
RDEE CO.
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Oak Creek Marsh
PEACE RIVER BASIN
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Long Point Marsh
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Lake Slough
13
Joshua Creek
Tiger Bay
Slippery Slough
Sheep Pen Marsh
Tiger Bay Slough
Sour Orange Hammock
Myrtle Slough
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DESOTO CO
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Long Island
Rainey Slough
Cypress Slough
CHARLOTTE CO
CALOOSAHATCHEE RIVER BASIN
LEGEND
● Domestic Discharge
▲ Industrial Discharge
Watershed Boundary (Adapted from Water Management Study of Four River Basins Area, Vol. II, Plate 3)
Southwest Florida Water Management District Eastern Boundary
■ Spring Location, Index Number Keyed to Text
⑤ River Segments (Described in Text)

CENTRAL FLORIDA PHOSPHATE EIS

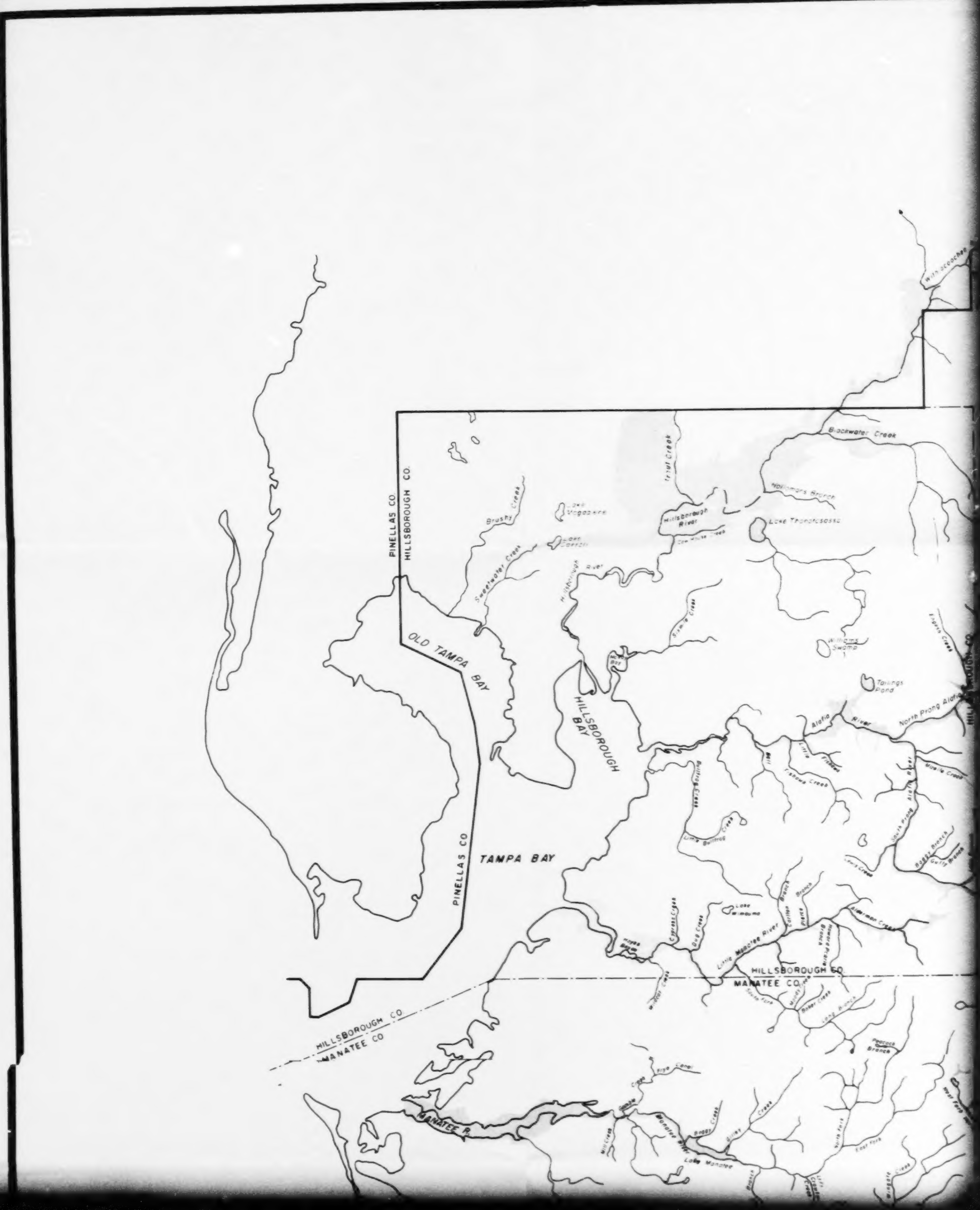
PLATE 1 Volume V

RIVER BASINS, RIVER SEGMENTS, SPRINGS, AND POINT SOURCE DISCHARGERS

Prepared by

TEXAS INSTRUMENTS
INCORPORATED

EPA Contract Number 68-01-4196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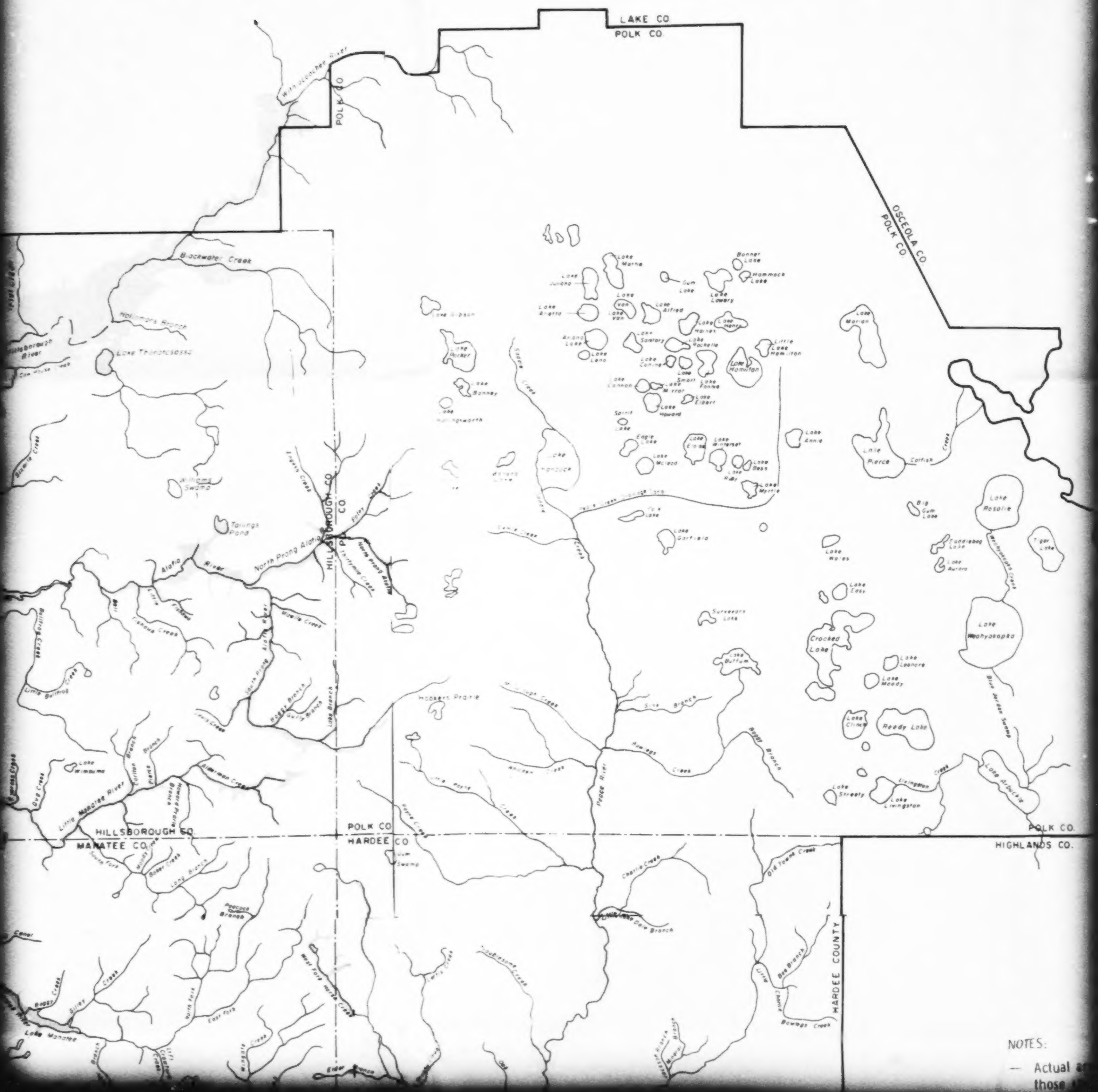
Trout Creek
Hollomans Branch
Hillsborough River
Cow House Creek
Lake Thonotosassa
Lake Vogabond
Brushy Creek
Lake Carroll
Sweetwater Creek
Hillsborough River
Sixmile Creek
McKay Bay
Williams Swamp
English Creek
Tailings Pond
North Prong Alafia
Alafia River
PINELLAS CO.
HILLSBOROUGH CO.
OLD TAMPA BAY
HILLSBOROUGH BAY
Bell
Little Fishhawk
Fishhawk Creek
Turkey Creek
Alafia River
South Prong Alafia River
Bullfrog Creek
Little Bullfrog Creek
Lewis Creek
Boggy Branch
Gully Branch
PINELLAS CO.
TAMPA BAY
Carlton Branch
Pierce Branch
Lake Wimauma
Alderman Creek
Cypress Creek
Dug Creek
Hayes Bayou
Little Manatee River
Howard Prairie Branch
HILLSBOROUGH CO.
MANATEE CO.
HILLSBOROUGH CO.
MANATEE CO.
Curiosity Creek
South Fork
Moody Creek
Baker Creek
Long Branch
Peacock Branch
Frye Canal
Gamble Creek
MANATEE R.
Mill Creek
Manatee River
Boggy Creek
Gilley Creek
Lake Manatee
North Fork
East Fork
West Fork
Branch
Wingate Creek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OSCEOLA CO.
POLK CO.
POLK CO.
HILLSBOROUGH CO.
PASCO CO.
HILLSBOROUGH CO.
POLK CO.
MANATEE CO.
HARDEE CO.
HIGHLANDS CO.
HARDEE COUNTY
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Blackwater Creek
Hollimans Branch
Hillsborough River
Lake Thonotosassa
Cow House Creek
Williams Swamp
Tailings Pond
Alafia River
North Prong Alafia
South Prong Alafia River
Little Fishhawk
Fishhawk Creek
Bullfrog Creek
Little Bullfrog Creek
Little Manatee River
Alderman Creek
Lake Wimauma
South Fork
Long Branch
Peacock Branch
Lake Manatee
Gilley Creek
Boggy Creek
Wingate Creek
East Fork
North Fork
West Fork Horse Creek
Elder Branch
Payne Creek
Hookers Prairie
Saddle Creek
Lake Hancock
Lake Parker
Lake Gibson
Lake Bonney
Lake Hollingsworth
Peace River
Peace Creek Drainage Canal
Lake Garfield
Lake Juliana
Lake Mattie
Gum Lake
Bonnet Lake
Hammock Lake
Lake Lowery
Lake Alfred
Lake Haines
Lake Henry
Lake Ariana
Lake Arietta
Lake Van
Lake Rochelle
Lake Hamilton
Little Lake Hamilton
Lake Conine
Lake Smart
Lake Fannie
Lake Cannon
Lake Mirror
Lake Elbert
Lake Howard
Spirit Lake
Eagle Lake
Lake Eloise
Lake Winterset
Lake McLeod
Lake Ruby
Lake Bess
Lake Myrtle
Lake Annie
Lake Marion
Little Pierce
Catfish Creek
Big Gum Lake
Lake Rosalie
Tiger Lake
Lake Aurora
Weohyakapka Creek
Lake Weohyakapka
Lake Wales
Lake Easy
Surveyors Lake
Crooked Lake
Lake Buffum
Lake Leonore
Lake Moody
Lake Clinch
Reedy Lake
Lake Streety
Lake Livingston
Livingston Creek
Lake Arbuckle
Bowlegs Creek
Bear Branch
Charlie Creek
Old Town Creek
Troublesome Creek
Little Charlie Creek
Canal

NOTES:
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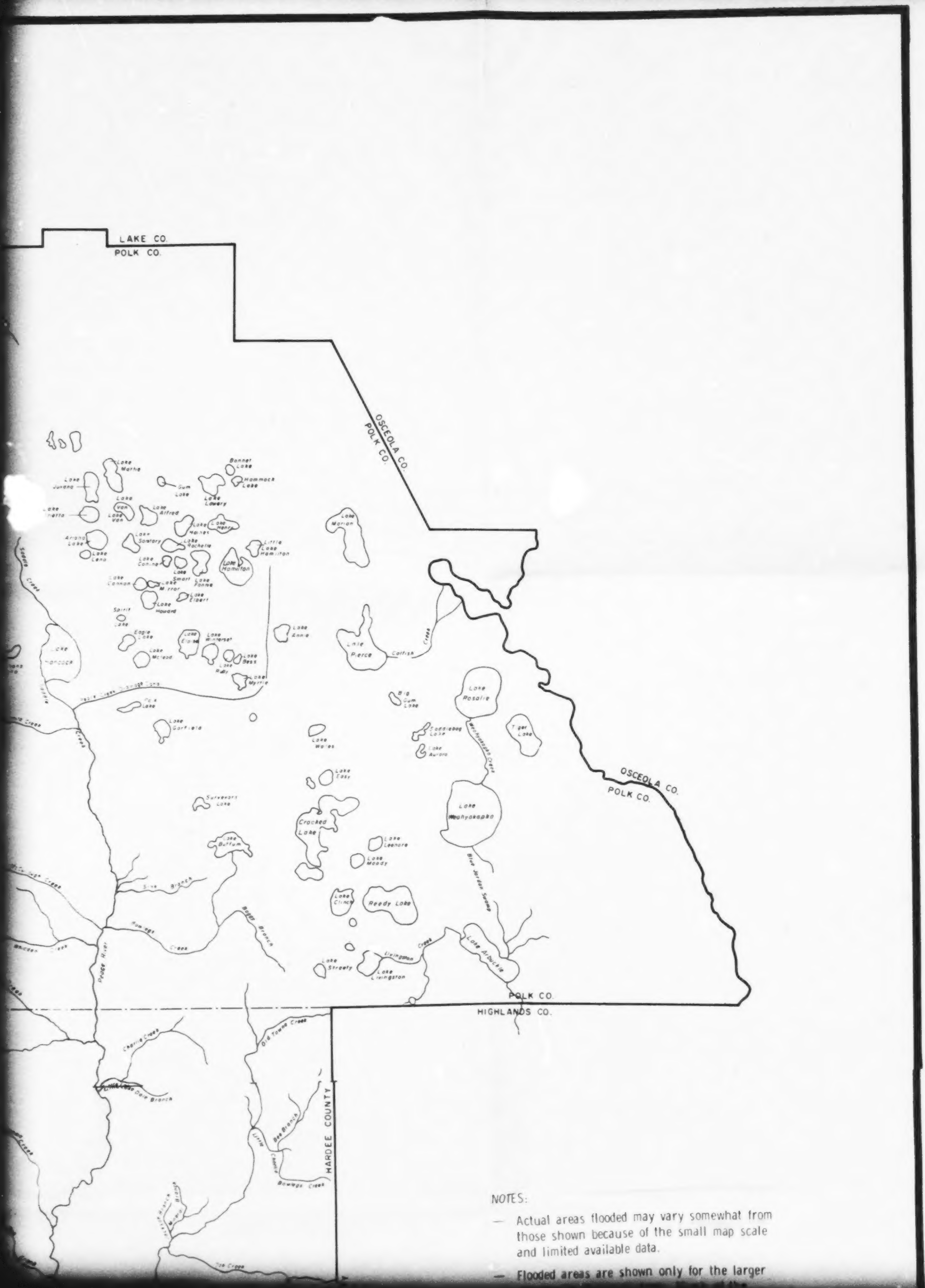
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POLK CO.
OSCEOLA CO.
POLK CO.
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Hammock Lake
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Lake Saratory
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Little Lake Hamilton
Lake Lena
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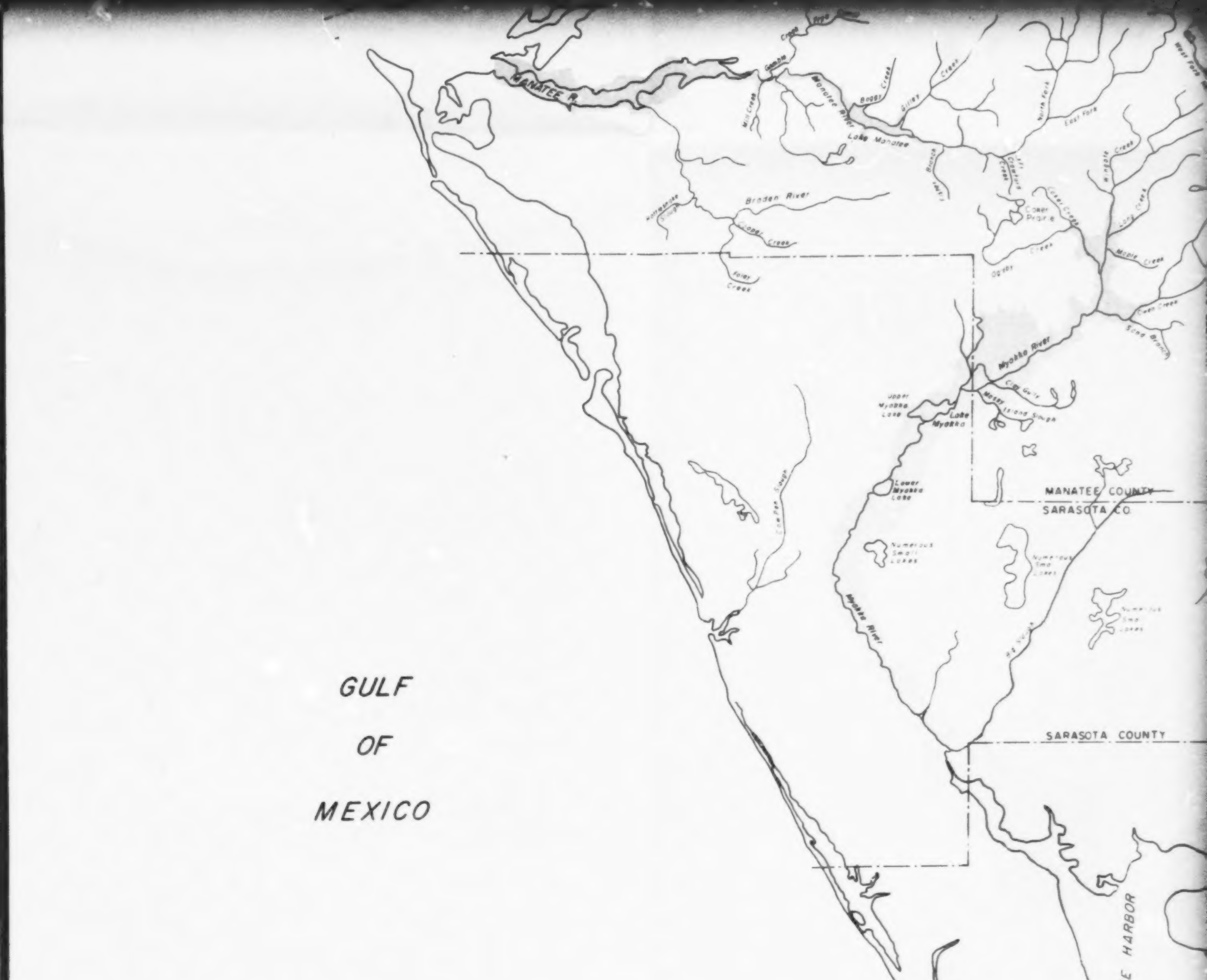
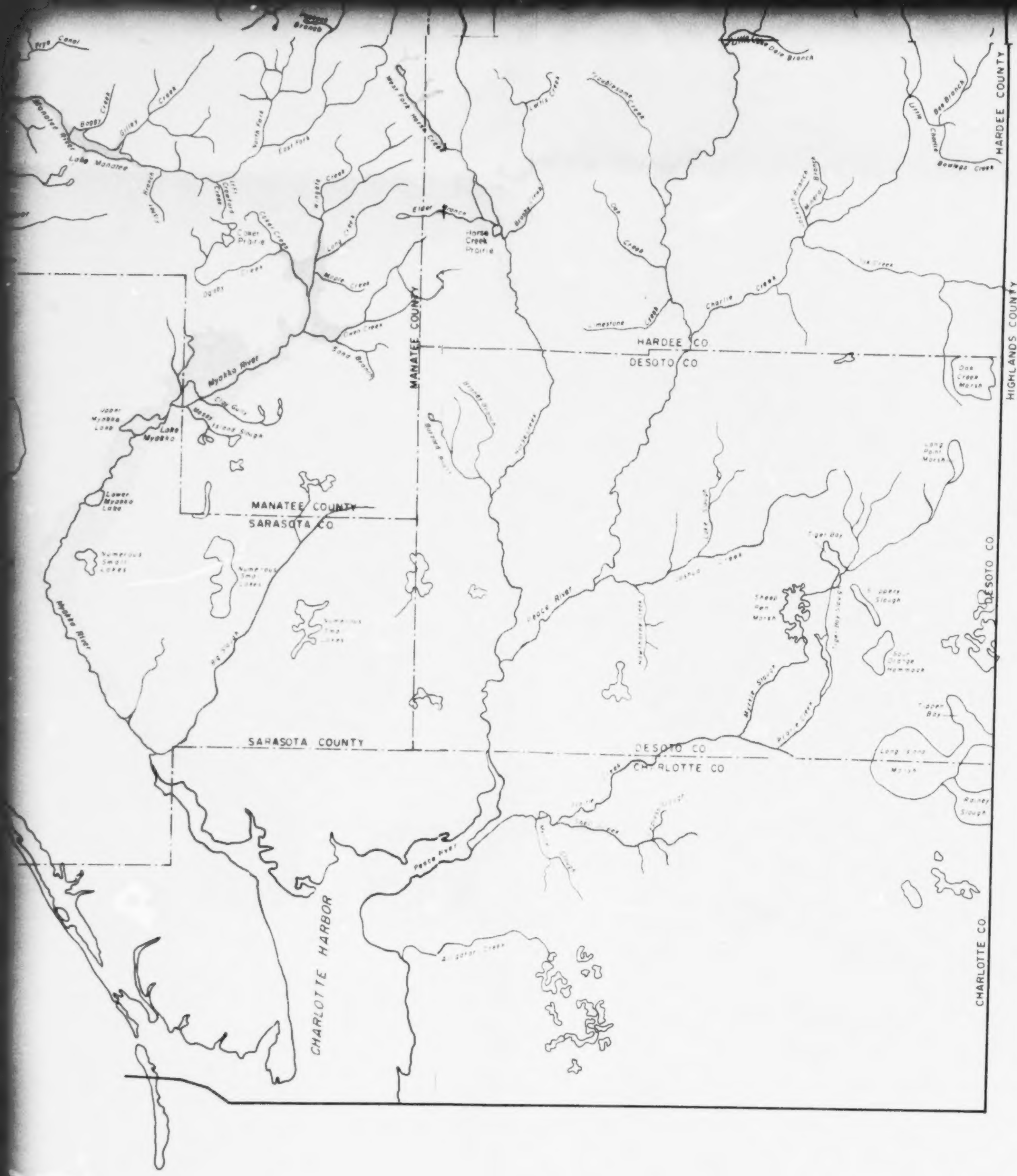
Lake Smart
Lake Fannie
Lake Cannon
Lake Mirror
Lake Elbert
Lake Howard
Spirit Lake
Saddle Creek
Lake Hancock
Eagle Lake
Lake Eloise
Lake Winterset
Lake Annie
Lake Mcleod
Lake Bess
Lake Ruby
Lake Myrtle
Lake Marion
Lake Pierce
Catfish Creek
Peace Creek Drainage Canal
Polk Lake
Lake Garfield
Big Gum Lake
Lake Rosalie
Saddlebag Lake
Lake Aurora
Lake Wales
Tiger Lake
Weohyakapka Creek
Lake Easy
Surveyors Lake
Crooked Lake
Lake Weohyakapka
Lake Buffum
Lake Leonore
Lake Moody
Blue Jordan Swamp
Sink Branch
McCullough Creek
Lake Clinch
Reedy Lake
Bowlegs Creek
Bogey Branch
Whidden Creek
Peace River
Lake Streety
Livingston Creek
Lake Livingston
Lake Arbuckle
POLK CO.
HIGHLANDS CO.
Old Town Creek
Charlie Creek
Little Lake Dale Branch
Bee Branch
Little Charlie
Bowlegs Creek
HARDEE COUNTY
Horse Creek
Brandy Branch
Jackson Branch
Troublesome Creek
Oak Creek

NOTES:

- Actual areas flooded may vary somewhat from those shown because of the small map scale and limited available data.
- Flooded areas are shown only for the larger


MANATEE R.
Gamble
Creek
Mill Creek
Manatee River
Boggy Creek
Gilley
Creek
North Fork
East Fork
West Fork
Lake Manatee
Branch
Lewis
Crawford
Creek
Rattlesnake Slough
Braden River
Cooper Creek
Foley Creek
Coker Prairie
Coker Creek
Wingate Creek
Long Creek
Maple Creek
Owen Creek
Sand Branch
Ogleby
Creek
Myakka River
Clay Gully
Mossy Island Slough
Upper Myakka Lake
Lake Myakka
Lower Myakka Lake
Cow Pen Slough
Numerous Small Lakes
Numerous Small Lakes
Numerous Small Lakes
Myakka River
Big Slough
MANATEE COUNTY
SARASOTA CO.
SARASOTA COUNTY
GULF
OF
MEXICO
CHARLOTTE HARBOR
N
SCALE
5 0 5 10 15 20 Statute Miles
5 0 5 10 15 20 25 30 Kilometers
5 0 5 10 15 Nautical Miles
LOCATION OF
STUDY AREA
WITHIN FLORIDA

Source: U.S. Geological Survey
Flood-Prone Area Maps,
1976, 7.5 Min. Quads


Frog Canal
Manatee River
Boggy Creek
Gilley Creek
Lake Manatee
North Fork
East Fork
West Fork Horse Creek
Lettis Creek
Troublesome Creek
Little Charlie Branch
Bee Branch
Bowlegs Creek
HARDEE COUNTY
Wingate Creek
Coker Prairie
Elder Branch
Horse Creek Prairie
Owen Creek
Myakka River
Upper Myakka Lake
Lake Myakka
Lower Myakka Lake
Numerous Small Lakes
MANATEE COUNTY
SARASOTA CO
HARDEE CO
DESOTO CO
HIGHLANDS COUNTY
Oak Creek Marsh
Long Point Marsh
Tiger Bay
Sheep Pen Marsh
Sour Orange Hammock
Peace River
Joshua Creek
Charlie Creek
Limestone Creek
Myrtle Slough
Prairie Creek
Long Island Marsh
Rainey Slough
SARASOTA COUNTY
DESOTO CO
CHARLOTTE CO
CHARLOTTE HARBOR
Alligator Creek
CHARLOTTE CO
DESOTO CO

NOTES:

— Actual
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— Flooded
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CENTRAL F

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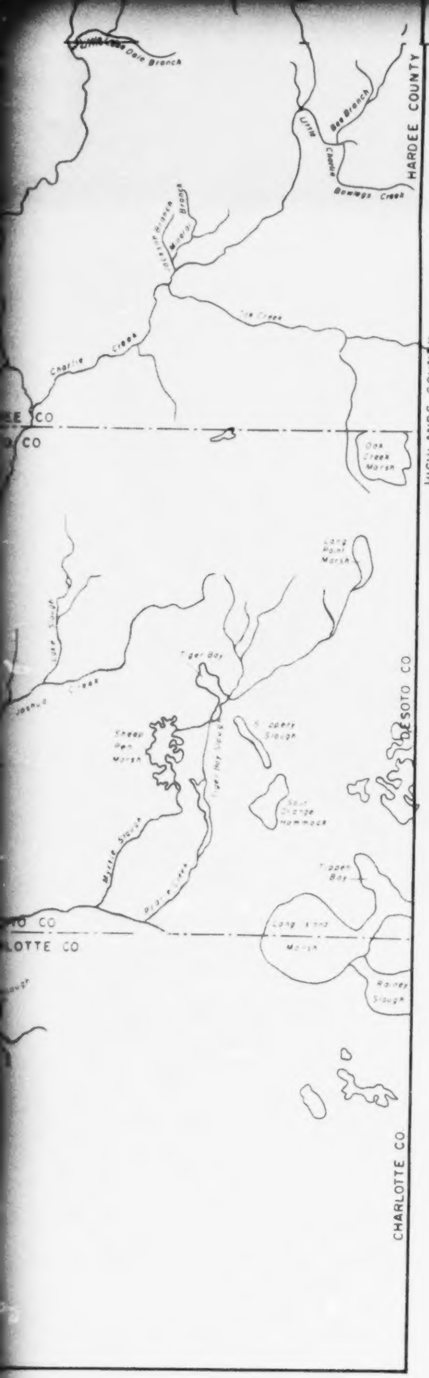

Little Lake Dale Branch
Bee Branch
Hickey
Charlie
Bowlegs Creek
HARDEE COUNTY
Jackson Branch
Minerals Branch
Tin Creek
Charlie Creek
EE CO
O CO
HIGHLANDS COUNTY
Oak Creek Marsh
Long Point Marsh
Lake Slough
Tiger Bay
Joshua Creek
Sheep Pen Marsh
Slippery Slough
Tiger Bay Slough
Sour Orange Hammock
Myrtle Slough
Prairie Creek
Tippen Bay
DE SOTO CO
O CO
Long Island Marsh
LOTTE CO
Rainey Slough
CHARLOTTE CO

NOTES:

- Actual areas flooded may vary somewhat from those shown because of the small map scale and limited available data.
- Flooded areas are shown only for the larger streams in the study area. Much of the area could be subject to shallow ponding or sheet flooding and is not indicated on the map.

CENTRAL FLORIDA PHOSPHATE EIS

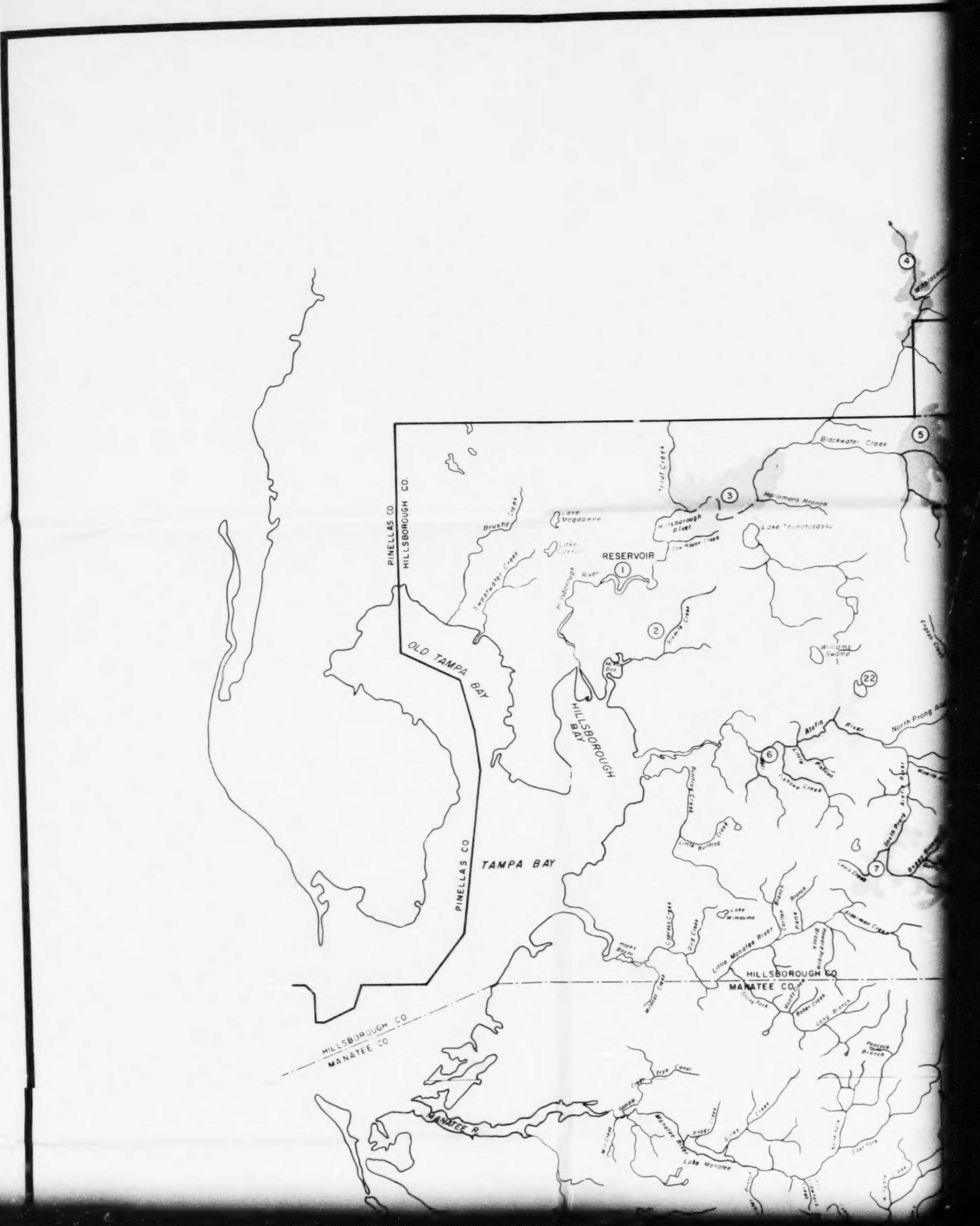
PLATE 2 Volume V

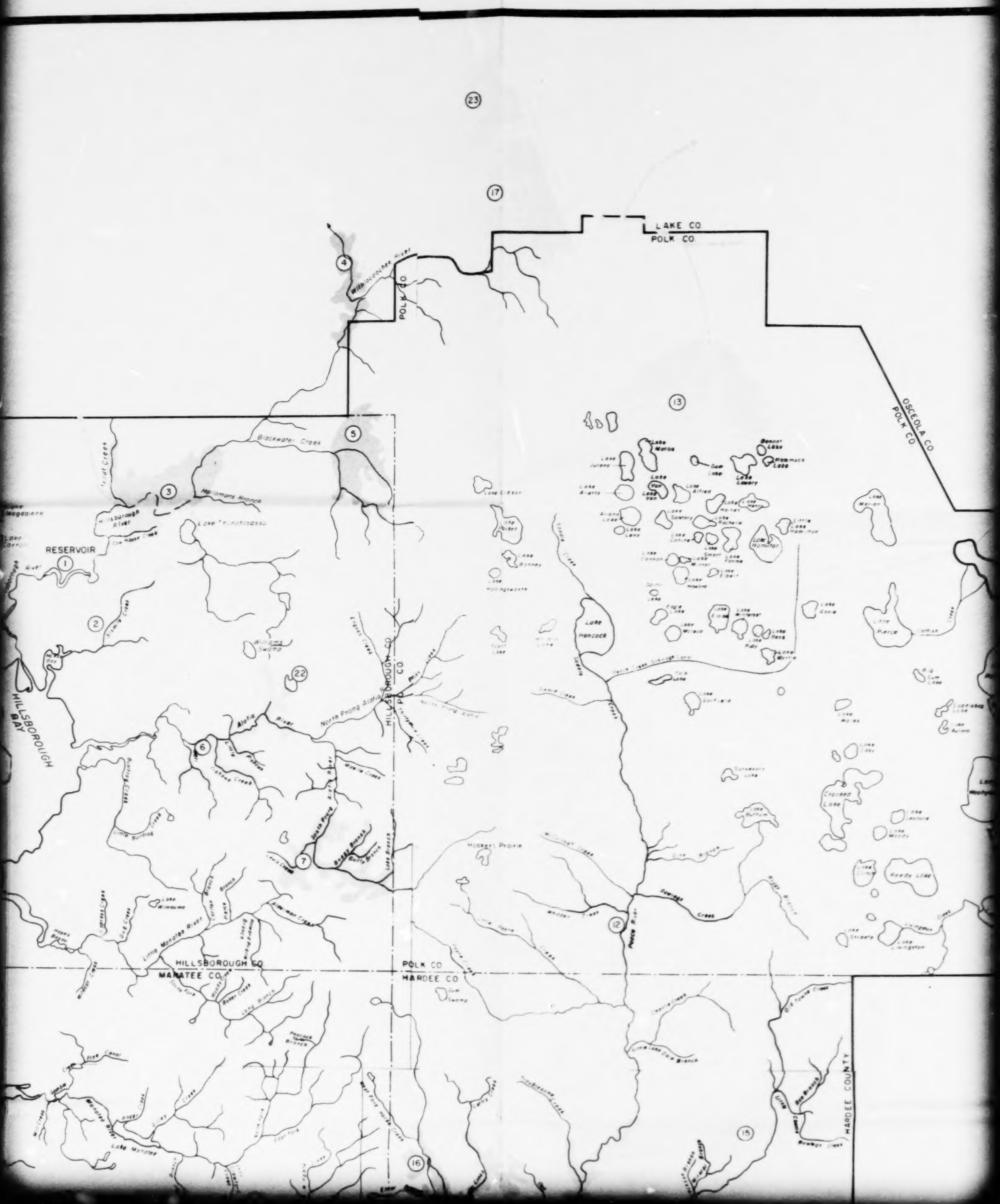
100-YEAR FLOOD-PRONE AREA

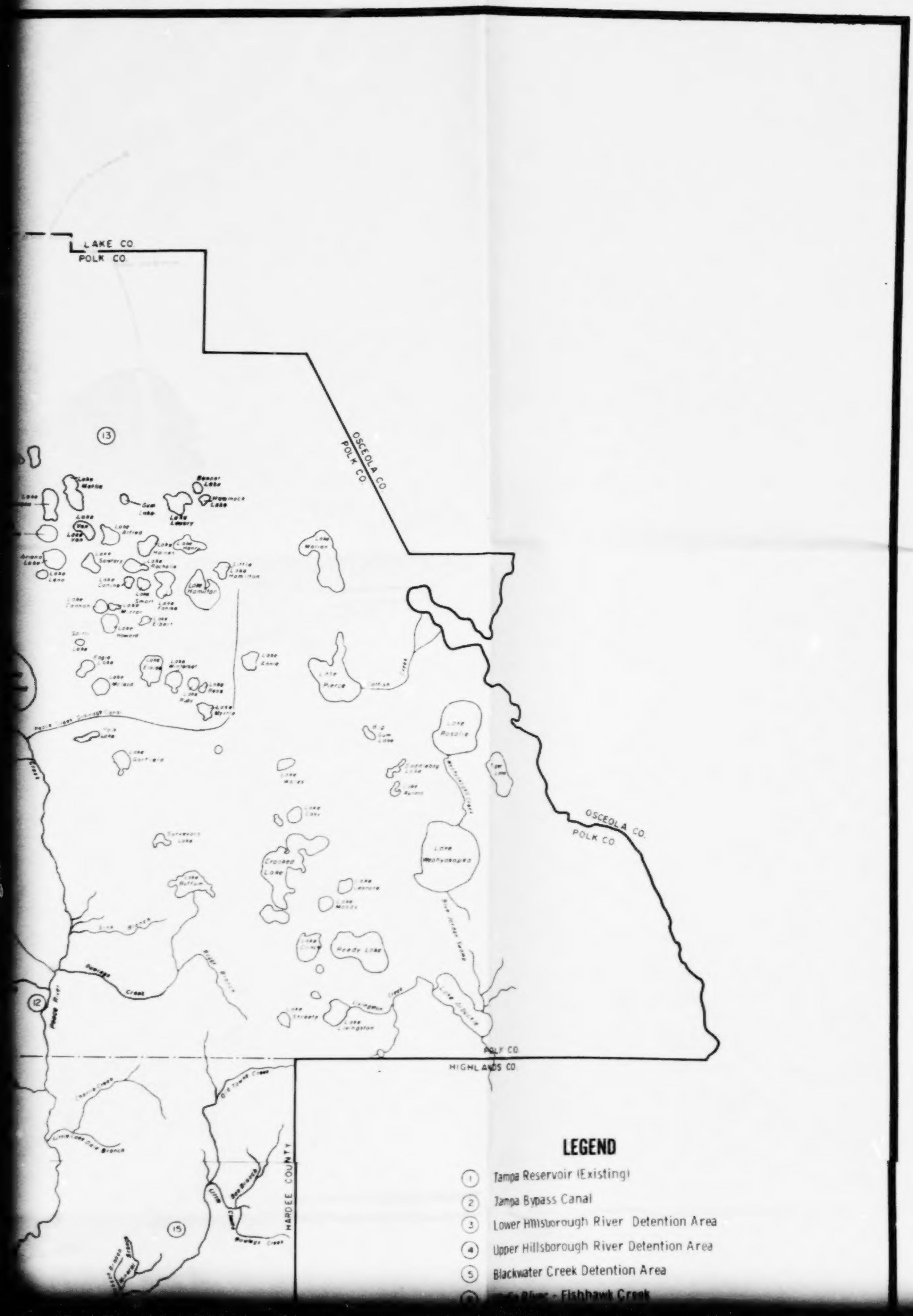
Prepared by

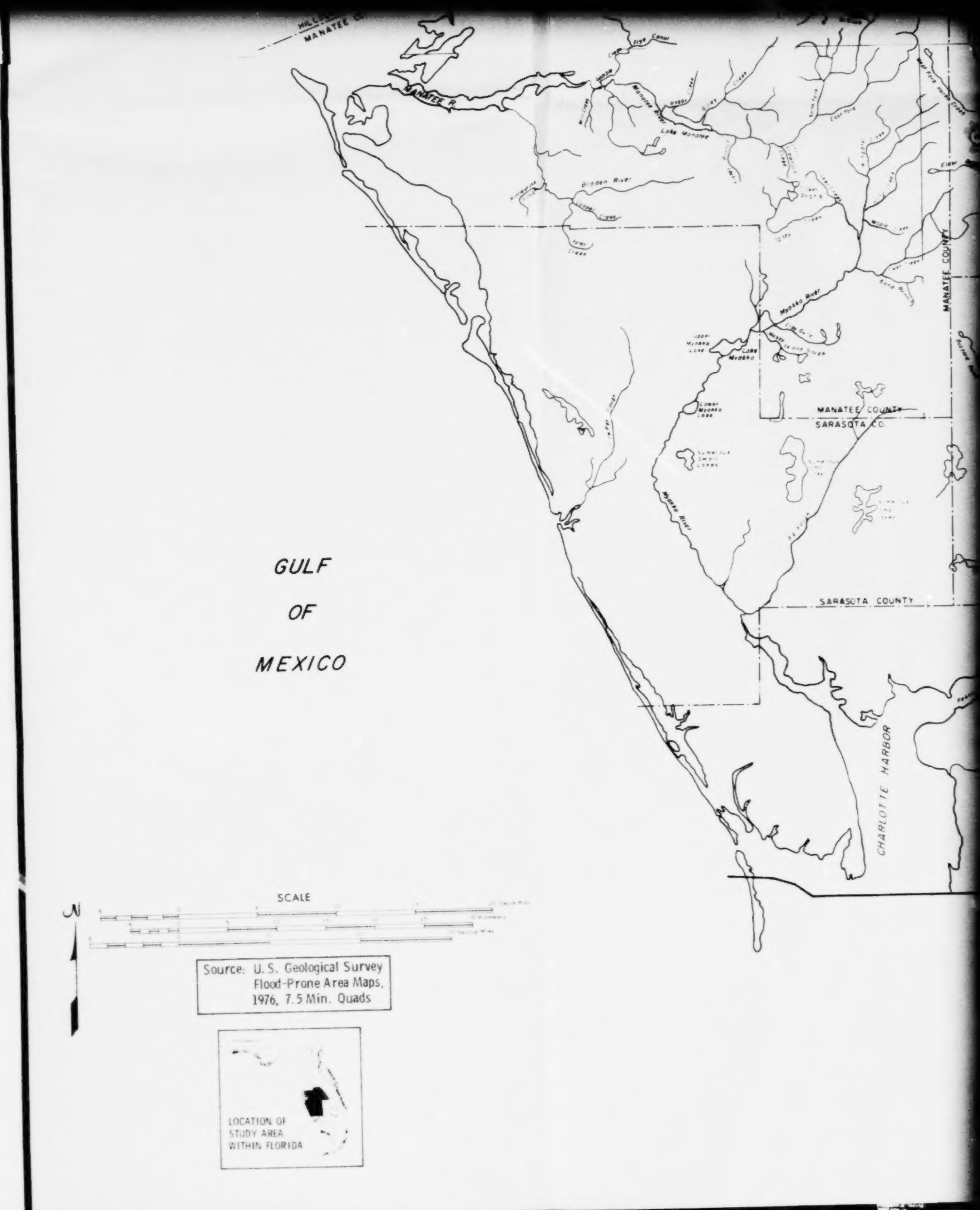
TEXAS INSTRUMENTS
INCORPORATED

EPA Contract Number 68-01-4196

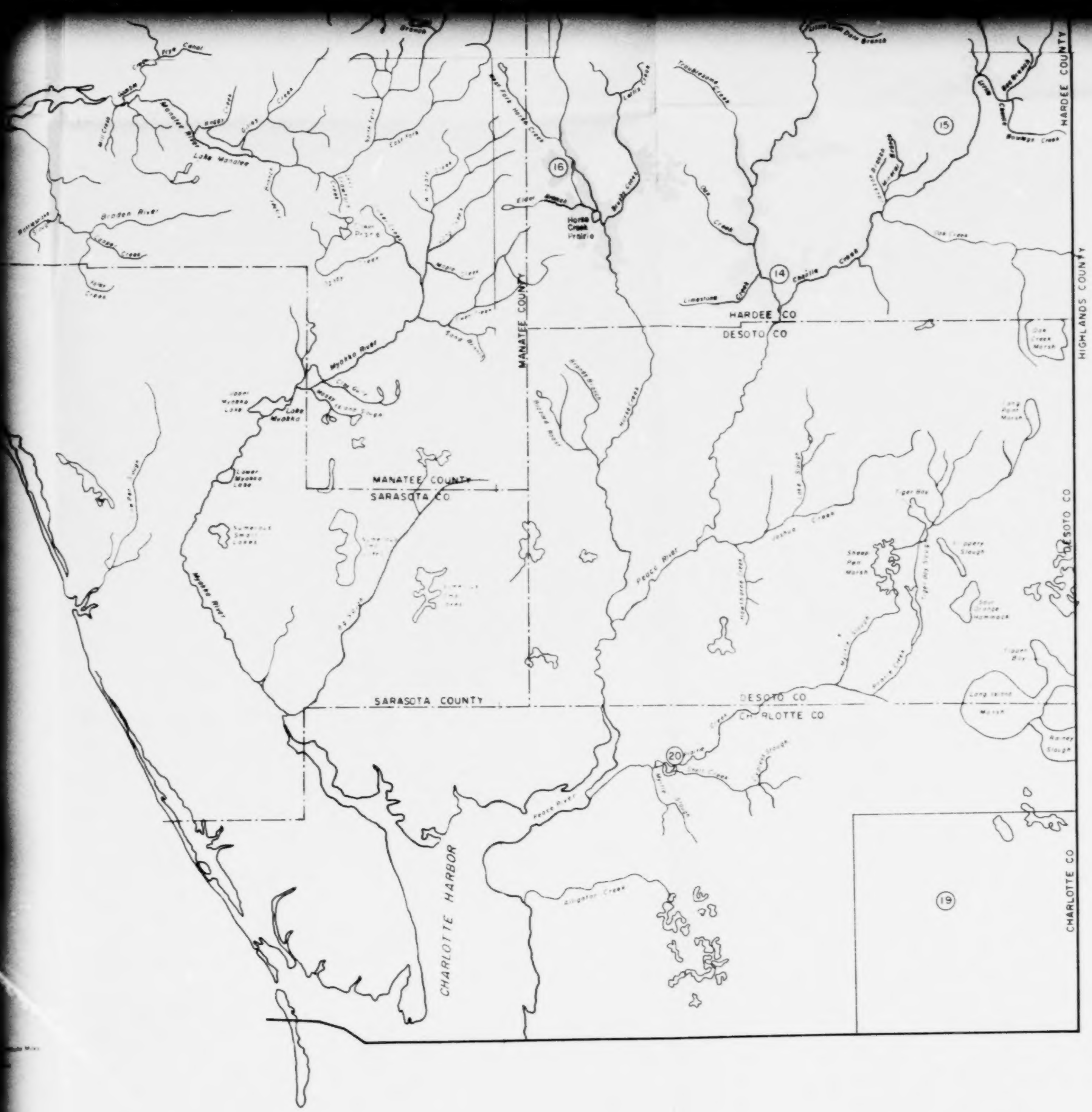

④
Withlacoochee
⑤
Blackwater Creek
Trout Creek
③
Hallomans Branch
Hillsborough River
Cow House Creek
Lake Thonotosassa
Lake Magdalene
Lake Carroll
Brushy Creek
Sweetwater Creek
RESERVOIR
①
Hillsborough River
②
Sixmile Creek
McKay Bay
Williams Swamp
22
PINELLAS CO.
HILLSBOROUGH CO.
OLD TAMPA BAY
HILLSBOROUGH BAY
PINELLAS CO
TAMPA BAY
Alafia River
North Prong Alafia
⑥
Little Fishhawk
Fishhawk Creek
Bullfrog Creek
Little Bullfrog Creek
South Prong Alafia River
⑦
Lewis Creek
Carlton Branch
Pierce Branch
Alderman Creek
Lake Wimauma
Cypress Creek
Dug Creek
Hayes Bayou
Little Manatee River
Howard Prairie Branch
HILLSBOROUGH CO.
MANATEE CO.
Wildcat Creek
South Fork
Moody Creek
Baker Creek
Long Branch
Peacock Branch
HILLSBOROUGH CO
MANATEE CO
Frye Canal
Gamble Creek
MANATEE R.
Mill Creek
Manatee River
Boggy Creek
Gilley Creek
Lake Manatee
East Fork
North Fork
English Creek

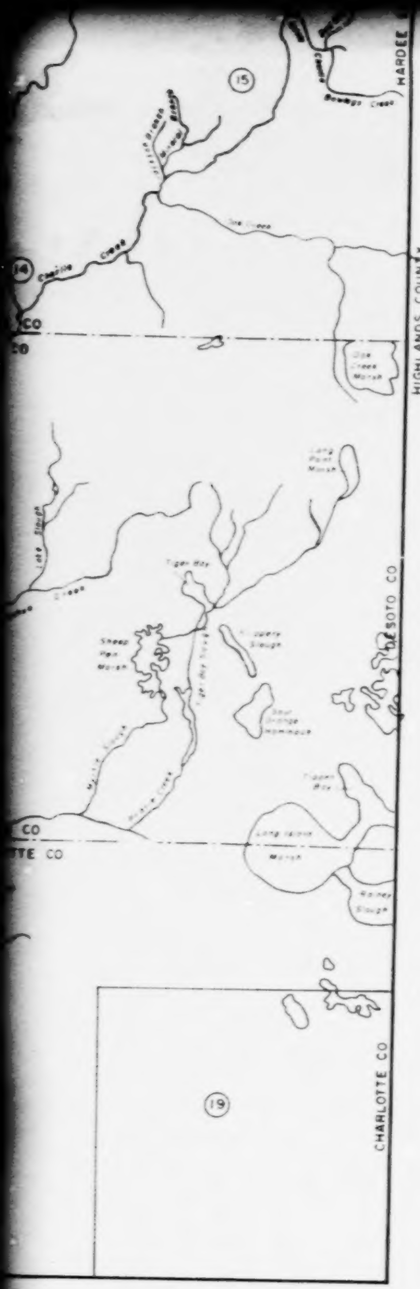

23
17
LAKE CO
POLK CO
OSCEOLA CO
POLK CO
4
Withlacoochee River
POLK CO
13
5
Blackwater Creek
Trout Creek
3
Hillsborough River
Hollomans Branch
Lake Thonotosassa
Lake Carroll
RESERVOIR
1
River
2
Williams Swamp
22
HILLSBOROUGH BAY
HILLSBOROUGH CO
POLK CO
North Prong Alafia
Alafia River
6
Fishhawk Creek
Little Bullfrog Creek
Turkey Creek
South Prong Alafia
7
Lake Branch
Little Manatee River
Alderman Creek
Carlton Branch
Lake Wimauma
Hayes Bayou
Cypress Creek
Dug Creek
HILLSBOROUGH CO
MANATEE CO
South Fork
Baker Creek
Long Branch
Peacock Branch
Frye Canal
Manatee River
Lake Manatee
Gilley Creek
East Fork
16
Lake Gibson
Lake Parker
Lake Bonney
Lake Hollingsworth
Scott Lake
Lake Hancock
Lake Juliana
Lake Mattie
Gum Lake
Lake Lowery
Bonnet Lake
Hammock Lake
Lake Arietta
Lake Van
Lake Alfred
Lake Haines
Lake Henry
Ariana Lake
Lake Shipp
Lake Lena
Lake Rochelle
Little Lake Hamilton
Lake Hamilton
Lake Conine
Lake Smart
Lake Fannie
Lake Cannon
Lake Mirror
Lake Eloise
Lake Howard
Lake Elbert
Eagle Lake
Lake Winterset
Lake McLeod
Lake Ruby
Lake Ross
Lake Mattie
Lake Annie
Polk Lake
Lake Garfield
Saddle Creek
Peace Creek Drainage Canal
Lake Marion
Little Lake Pierce
Catfish Creek
Big Gum Lake
Lake Weohyakapka
Lake Aurora
Lake Caloosa
Crooked Lake
Lake Buffum
Lake Leonore
Lake Moody
Lake Clinch
Reedy Lake
Lake Livingston
Hookers Prairie
Sink Branch
Bowlegs Creek
Whidden Creek
12
Peace River
Payne Creek
POLK CO
HARDEE CO
Gum Swamp
Charlie Creek
Little Charley Bowlegs Creek
Troublesome Creek
Oak Creek
15
HARDEE COUNTY
Bee Branch
Bowlegs Creek


LAKE CO.
POLK CO.
OSCEOLA CO.
POLK CO.
OSCEOLA CO.
POLK CO.
POLK CO.
HIGHLANDS CO.
HARDEE COUNTY
(13)
(12)
(15)
Lake Mattie
Lake Van
Lake Alfred
Gum Lake
Lake Lowery
Hammock Lake
Arlana Lake
Lake Lena
Lake Haines
Lake Henry
Lake Rochelle
Little Lake Hamilton
Lake Hamilton
Lake Conine
Lake Smart
Lake Fannie
Lake Cannon
Lake Mirror
Lake Elbert
Lake Howard
Spirit Lake
Eagle Lake
Lake Eloise
Lake Winterset
Lake McLeod
Lake Ruby
Lake Rosa
Lake Mariana
Lake Annie
Lake Pierce
Catfish Creek
Lake Marion
Peace Creek Drainage Canal
Lake Garfield
Big Gum Lake
Lake Rosalie
Saddlebag Lake
Lake Aurora
Tiger Lake
Lake Wales
Crooked Lake
Lake Weohyakapka
Lake Leonore
Lake Moody
Reedy Lake
Lake Clinch
Lake Buffum
Blue Jordan Swamp
Lake Arbuckle
Livingston Creek
Lake Livingston
Lake Streety
Saddle Creek
Peace River
Old Town Creek
Little Charlie Creek
Bee Branch
LEGEND
① Tampa Reservoir (Existing)
② Tampa Bypass Canal
③ Lower Hillsborough River Detention Area
④ Upper Hillsborough River Detention Area
⑤ Blackwater Creek Detention Area
River - Fishhawk Creek


MANATEE CO.
Frye Canal
MANATEE R.
Manatee River
Lake Manatee
Braden River
Myakka River
Upper Myakka Lake
Lake Myakka
Lower Myakka Lake
Numerous Small Lakes
East Fork
Horse Creek
MANATEE COUNTY
SARASOTA CO.
SARASOTA COUNTY
CHARLOTTE HARBOR
GULF
OF
MEXICO
SCALE
N
LOCATION OF
STUDY AREA
WITHIN FLORIDA

Source: U.S. Geological Survey
Flood-Prone Area Maps,
1976, 7.5 Min. Quads


Frye Canal
Manatee River
Lake Manatee
Mill Creek
Gilley Creek
East Fork
Braden River
Cooper Creek
Myakka River
Upper Myakka Lake
Lake Myakka
Lower Myakka Lake
Numerous Small Lakes
Maple Creek
Sand Branch
Elder Branch
Horse Creek Prairie
West Fork Horse Creek
Brushy Creek
Troublesome Creek
Little Lake Dale Branch
Oak Creek
Limestone Creek
Charlie Creek
Bowlegs Creek
Brandy Branch
Buzzard Roost
Horse Creek
Lake Slough
Joshua Creek
Peace River
Hawthorne Creek
Tiger Bay
Tiger Bay Slough
Sheep Pen Marsh
Sour Orange Hammock
Long Point Marsh
Oak Creek Marsh
Long Island Marsh
Rainey Slough
Prairie Creek
Shell Creek
Myrtle Slough
Alligator Creek
CHARLOTTE HARBOR
16
15
14
20
19
MANATEE COUNTY
SARASOTA CO.
SARASOTA COUNTY
HARDEE CO
DESOTO CO
CHARLOTTE CO.
HARDEE COUNTY
HIGHLANDS COUNTY



① Tampa Reservoir (Existing)
② Tampa Bypass Canal
③ Lower Hillsborough River Detention Area
④ Upper Hillsborough River Detention Area
⑤ Blackwater Creek Detention Area
⑥ Alafia River - Fishhawk Creek
⑦ Alafia River - South Prong
⑧ Pleasant Grove Reservoir (Existing)
⑨ Manatee River - North and East Forks
⑩ Myakka River - Tatum Sawgrass
⑪ Myakka River - Long and Ogleby Creeks
⑫ Peace River - Whidden Creek
⑬ Lowery - Mattie Conservation Area
⑭ Peace River - Charlie and Limestone Creeks
⑮ Charlie Creek
⑯ Horse Creek
⑰ Green Swamp Detention Area
⑱ Lake Manatee (Existing)
⑲ Telegraph Swamp
⑳ Shell and Prairie Creeks Reservoir (Existing)
㉑ Big Slough Canal (Existing)
㉒ Braden Reservoir (Existing)
㉓ Little Withlacoochee River Detention Area

CURRENT DEVELOPMENT

Canal Completed or Under Construction
Proposed Canal
Proposed Levee
Proposed Culvert
Proposed Spillway

CENTRAL FLORIDA PHOSPHATE EIS

PLATE 3 - Volume V

EXISTING AND PROPOSED SURFACE-WATER SYSTEMS

Prepared by

TEXAS INSTRUMENTS

EPA Contract Number 68-01-4196

CHARACTERISTIC WATER QUALITY FOR STUDY AREA,

Designation on Map		Alkalinity (mg/ℓ $CaCO_3$)	BOD_5 (mg/ℓ)	Color (Pt. Co unit)	Conductivity (mho/cm)	Dissolved Oxygen (mg/ℓ)	Fluoride (mg/ℓ)	Nitrate-N (mg/ℓ)	Ammonia-N (mg/ℓ)	Organic-N (mg/ℓ)
P.1	Max	202	4.0	160	487	15.0	14.0	5.70	1.90	4.02
	Min	54	0.5	30	230	0.6	0.3	0.00	0.01	0.04
	Avg	105	2.0	63	352	6.2	3.6	0.20	0.17	0.62
P.2	Max	182	7.7	40	439	10.8	3.4	0.57	0.43	1.76
	Min	16	1.7	40	80	0.6	0.0	0.00	0.01	0.13
	Avg	106	4.0*	40#	273	4.7	0.6	0.14	0.15	1.33
P.3	Max	168	8.1	200	790	10.9	5.2	2.10	0.93	13.00
	Min	13	1.2	3	210	1.7	0.9	0.00	0.01	0.29
	Avg	81	3.4	64	439	4.8	2.6	0.33	0.18	1.88
P.4	Max	226	8.4	20	600	10.7	7.0	2.00	4.55	8.96
	Min	20	0.4	20	230	1.0	0.6	0.00	0.01	0.41
	Avg	104	3.2	20#	426	5.9	2.3	0.75	0.43	1.39
P.5	Max	216	9.5	–	–	8.1	15.5	9.40	29.40	1.72
	Min	20	0.7	–	–	4.0	0.6	0.00	0.00	0.08
	Avg	85	5.4*	–	–	5.5*	3.9	0.89	1.47	0.88
P.6	Max	158	3.6	–	–	9.0	1.6	2.20	0.14	0.77
	Min	10	1.1	–	–	5.8	0.3	0.00	0.01	0.45
	Avg	64	2.0#	–	–	7.7#	1.0	0.50	0.05	0.60
P.7	Max	178	78.0	252	530	10.3	18.0	4.30	3.80	7.95
	Min	8	0.0	0	3	0.4	0.2	0.00	0.00	0.48
	Avg	84	15.6	91*	219*	5.1	2.1	1.23	0.44	1.18
P.8	Max	212	2.5	–	–	8.9	1.7	3.65	0.28	1.27
	Min	18	1.6	–	–	5.6	0.7	0.00	0.01	0.29
	Avg	68	2.1#	–	–	7.1#	1.2	1.25	0.13	0.83
P.9	Max	600	6.3	140	742	9.2	8.6	4.60	2.36	1.90
	Min	44	0.1	0	130	0.0	0.5	0.00	0.00	0.38
	Avg	76	2.0	55	413	6.3	1.4	1.23	0.22	0.91
P.10	Max	61	1.7	200	300	9.6	0.6	–	–	0.59
	Min	16	0.7	10	93	4.5	0.3	–	–	0.55
	Avg	42#	1.2#	83#	180	7.1	0.5#	–	–	0.57#
P.11	Max	176	3.7	280	630	11.8	2.7	3.90	0.42	2.12
	Min	15	0.1	0	100	2.3	0.5	0.00	0.00	0.27
	Avg	54	1.7	86	358	7.4	1.4	1.13	0.11	0.92
P.12	Max	73	3.1	220	605	9.5	2.4	2.02	0.37	2.56
	Min	34	0.1	30	300	4.8	0.4	0.00	0.02	0.52
	Avg	49#	1.4	104#	446#	6.4	1.2#	1.00	0.16	1.33#
P.13	Max	46	4.8	240	990	–	0.1	0.00	0.01	1.50
	Min	0	4.8	240	151	–	0.1	0.00	0.01	0.92
	Avg	30#	4.8#	240#	491	–	0.1#	0.00#	0.01#	1.21#
P.14	Max	74	2.5	300	750	9.0	1.4	2.00	0.45	2.50
	Min	38	0.3	30	260	4.0	0.5	0.00	0.04	0.54
	Avg	51#	1.2	130	540#	6.2	0.9#	0.64	0.16	1.35
A.1	Max	106	3.0	30	200	6.6	0.8	–	–	0.53
	Min	57	1.5	30	200	7.5	0.8	–	–	0.53
	Avg	86#	2.3#	30#	200#	7.1#	0.8#	–	–	0.53#
A.2	Max	132	2.5	10	680	7.7	29.0	2.80	16.30	1.60
	Min	14	1.8	10	680	5.4	1.8	0.01	0.04	0.55
	Avg	47	2.2#	10#	680#	4.4#	12.3	0.81	4.31	0.94
A.3	Max	176	2.1	10	660	7.2	12.0	2.60	7.20	2.30
	Min	24	2.1	10	660	7.2	2.8	0.00	0.00	2.00
	Avg	119#	2.1#	10#	660#	7.2#	5.7*	0.43*	1.18*	2.20#
A.4	Max	90	–	–	–	6.6	4.6	1.00	3.70	0.70
	Min	12	–	–	–	6.6	0.5	0.00	0.00	0.56
	Avg	47	–	–	–	6.6#	2.1	0.25	0.19	0.63#
A.5	Max	158	2.6	30	560	8.0	44.0	3.00	1.75	1.47
	Min	14	2.6	30	560	8.0	0.5	0.00	0.00	0.25
	Avg	76	2.6#	30#	560#	8.0#	3.8	0.94	0.24	0.87

ITY FOR STUDY AREA, JANUARY 1970-DECEMBER 1976

itrate-N (mg/ℓ)	Ammonia-N (mg/ℓ)	Organic-N (mg/ℓ)	pH (pH unit)	Ortho Phosphate (mg/ℓ)	Total Phosphate (mg/ℓ)	Temperature (°C)	Turbidity (JTU)	TOC (mg/ℓ)	Hardness (mg/ℓ)	Total Coliform[†] (No./100 mℓ)
5.70	1.90	4.02	9.2	–	–	30.0	32.0	57.0	–	94
0.00	0.01	0.04	6.5	–	–	10.0	1.0	5.5	–	2
0.20	0.17	0.62	7.7	–	–	24.7	6.7	26.3*	–	19*
0.57	0.43	1.76	8.1	–	–	31.0	25.0	34.0	90	–
0.00	0.01	0.13	6.5	–	–	12.3	15.0	4.0	90	–
0.14	0.15	1.33	7.4	–	–	24.1	20.0#	24.8#	90#	–
2.10	0.93	13.00	7.8	–	52.00	35.0	150.0	47.0	230	–
0.00	0.01	0.29	4.8	–	0.04	10.0	1.0	8.0	61	–
0.33	0.18	1.88	6.9	–	10.41	23.8	19.1	21.3	130	–
2.00	4.55	8.96	8.7	–	–	31.0	215.0	28.0	200	5,000
0.00	0.01	0.41	5.6	–	–	14.0	2.9	5.0	200	400
0.75	0.43	1.39	7.4	–	–	24.0	59.8#	13.8*	200#	2,700#
9.40	29.40	1.72	8.5	–	–	31.0	86.0	–	–	–
0.00	0.00	0.08	6.1	–	–	12.8	6.5	–	–	–
0.89	1.47	0.88	7.2	–	–	24.3	40.2#	–	–	–
2.20	0.14	0.77	8.0	–	–	28.0	1.8	–	–	–
0.00	0.01	0.45	5.8	–	–	10.0	1.8	–	–	–
0.50	0.05	0.60	7.1	–	–	21.8	1.8#	–	–	–
4.30	3.80	7.95	8.7	5.56	–	30.0	20.0	28.0	–	5,100
0.00	0.00	0.48	4.0	4.81	–	11.1	2.1	3.0	–	100
1.23	0.44	1.18	7.3	5.19#	–	23.2	6.2	12.3*	–	1,219*
3.65	0.28	1.27	7.9	–	–	28.0	–	–	–	–
0.00	0.01	0.29	6.7	–	–	11.7	–	–	–	–
1.25	0.13	0.83	7.3	–	–	23.1	–	–	–	–
4.60	2.36	1.90	8.4	4.86	21.00	38.0	241.0	17.0	260	9,000
0.00	0.00	0.38	4.2	4.86	1.90	11.1	2.0	6.9	98	250
1.23	0.22	0.91	7.3	4.86#	4.09	23.0	160.8	12.0#	166	2,735#
–	–	0.59	8.0	–	–	31.0	6.0	35.0	77	–
–	–	0.55	6.7	–	–	13.0	5.0	0.0	38	-
–	–	0.57#	7.3#	–	–	25.2	5.5#	17.1#	61#	–
3.90	0.42	2.12	–	1.00	10.00	31.5	59.0	20.0	250	7,000
0.00	0.00	0.27	–	1.00	0.03	10.0	0.0	4.0	38	2
1.13	0.11	0.92	–	1.00#	2.77	22.2	5.4	10.1	139	667*
2.02	0.37	2.56	8.1	–	–	29.0	56.0	–	–	910
0.00	0.02	0.52	7.0	–	–	10.0	2.0	–	–	330
1.00	0.16	1.33#	7.4#	–	–	23.4	9.2#	–	–	633#
0.00	0.01	1.50	4.3	0.02	0.18	30.0	8.0	20.5	94	–
0.00	0.01	0.92	4.3	0.02	0.04	2.4	8.0	20.5	9	–
0.00#	0.01#	1.21#	4.3#	0.02#	0.11#	23.5	8.0#	20.5#	64#	–
2.00	0.45	2.50	8.2	–	–	29.0	19.0	–	–	580
0.00	0.04	0.54	6.4	–	–	10.0	1.0	–	–	110
0.64	0.16	1.35	7.4#	–	–	23.4	4.6#	–	–	355
–	–	0.53	7.8	–	–	22.5	25.0	–	84	–
–	–	0.53	7.8	–	–	19.4	25.0	–	84	–
–	–	0.53#	7.8#	–	–	21.0#	25.0#	–	84#	–
2.80	16.30	1.60	7.6	–	–	29.0	13.0	–	246	–
0.01	0.04	0.55	4.9	–	–	12.2	13.0	–	246	–
0.81	4.31	0.94	6.2	–	–	23.8	13.0#	–	246#	–
2.60	7.20	2.30	8.0	–	8.10	29.0	16.0	–	232	–
0.00	0.00	2.00	4.0	–	3.10	12.2	16.0	–	232	–
0.43*	1.18*	2.20#	6.5#	–	5.60#	24.0#	16.0#	–	232#	–
1.00	3.70	0.70	8.1	–	–	28.0	–	–	–	–
0.00	0.00	0.56	4.4	–	–	13.3	–	–	–	–
0.25	0.19	0.63#	7.0	–	–	22.4	–	–	–	–
3.00	1.75	1.47	9.2	68.00	–	29.0	28.0	–	111	–
0.00	0.00	0.25	5.5	1.40	–	12.0	28.0	–	111	–
0.94	0.24	0.87	7.3	21.09	–	22.3	28.0#	–	111#	–

A.4	Max	90	–	–	–	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
	Min	12	–	–	–	6.6	0.5	0.00	0.00	0.56	
	Avg	47	–	–	–	6.6#	2.1	0.25	0.19	0.63#	7.
A.5	Max	158	2.6	30	560	8.0	44.0	3.00	1.75	1.47	9.2
	Min	14	2.6	30	560	8.0	0.5	0.00	0.00	0.25	5.5
	Avg	76	2.6#	30#	560#	8.0#	3.8	0.94	0.24	0.87	7.3
A.6	Max	57	1.3	60	1,530	10.4	22.0	4.00	11.80	2.10	7.7
	Min	2	0.0	10	221	2.2	1.9	0.00	0.00	0.06	4.8
	Avg	34	0.7	32	833	7.0	10.7	0.91	0.70	0.58	6.7
A.7	Max	120	8.9	110	393	11.0	0.8	4.00	1.64	1.10	8.
	Min	4	0.8	14	152	1.1	0.3	0.00	0.01	0.46	5.8
	Avg	48	2.3	34*	222	6.2	0.6	0.79	0.23	0.80	7.1
A.8	Max	258	–	–	–	5.4	44.0	1.00	15.00	4.88	9.1
	Min	16	–	–	–	1.4	0.3	0.00	0.00	0.65	4.4
	Avg	64	–	–	–	3.0#	6.2	0.24	0.35	1.14	6.8
A.9	Max	148	1.3	160	2,450	10.0	6.6	1.20	1.10	1.70	8.0
	Min	2	0.4	2	171	0.8	0.5	0.00	0.00	0.31	6.2
	Avg	52	1.0	63	382	6.5	3.3	0.28	0.11	0.78	7.0
A.10	Max	680	3.7	130	1,140	10.2	55.0	7.10	[illegible]	2.72	8.
	Min	0	0.1	10	210	1.8	0.3	0.00	0.00	0.04	5.
	Avg	57	1.1	49	599	7.0	5.8	0.63	0.22	0.69	7.
A.11	Max	120	8.5	114	1,280	12.1	14.4	4.82	1.83	0.27	7.
	Min	20	0.2	5	152	3.9	0.2	0.15	0.06	0.02	7.
	Avg	46*	2.6*	39*	566*	6.7*	5.6*	1.45*	0.38*	0.13#	7.
A.12	Max	310	11.1	43	45,900	12.8	12.0	4.24	1.27	2.10	8.5
	Min	20	0.0	5	14,000	0.3	0.7	0.00	0.00	0.00	6.7
	Avg	76	2.6	15	33,049	6.1	4.6	0.57	0.16	0.78	7.9
H.1	Max	272	33.0	160	1,580	12.5	6.0	5.00	5.20	1.50	8.
	Min	0	0.2	0	58	1.7	0.0	0.00	0.01	0.15	6.
	Avg	124	4.4	56	337	5.9	0.6	0.86	0.37	0.73	7.5
H.2	Max	212	9.0	200	614	10.6	1.6	3.00	0.73	5.40	9.
	Min	23	0.1	3	134	1.7	0.1	0.00	0.00	0.00	4.
	Avg	97	2.9	55	305	6.1	0.5	0.20	0.10	1.27	7.
H.3	Max	146	3.6	140	419	10.5	–	3.90	3.70	1.60	8.
	Min	68	0.4	4	140	0.9	–	0.00	0.00	0.08	4.
	Avg	113	1.3	50	299	4.7	–	0.48	0.18	0.73	7.
H.4	Max	127	5.0	80	9,800	8.6	0.6	1.31	0.08	1.80	8.
	Min	13	0.8	20	110	1.5	0.2	0.01	0.01	0.06	7.
	Avg	97#	2.2+	50#	907	6.1	0.3	0.13*	0.05#	0.54*	7
LM.1	Max	10	1.2	120	1,260	10.2	0.4	–	–	0.69	7
	Min	10	0.4	120	62	3.1	0.4	–	–	0.46	6
	Avg	10#	0.9+	120#	157	6.6	0.4#	–	–	0.58#	6
LM.2	Max	22	2.7	140	890	10.2	0.3	0.29	0.04	1.00	7
	Min	22	0.3	140	70	2.0	0.3	0.29	0.04	0.37	6
	Avg	22#	1.2+	140#	186	5.2	0.3#	0.29#	0.04#	0.59#	7
LM.3	Max	66	8.7	160	1,500	11.6	1.3	0.39	0.16	1.40	7
	Min	3	0.1	5	75	3.4	0.2	0.00	0.00	0.02	7
	Avg	26	1.4	66	199	7.3	0.5	0.17	0.05	0.58	7
LM.4	Max	78	2.0	50	291	8.0	2.8	0.15	2.00	3.30	7
	Min	22	0.5	27	131	0.8	0.4	0.01	0.10	0.78	7
	Avg	50#	1.3#	39#	207	3.6	1.6#	0.10#	1.05#	2.04#	7
M.1	Max	42	5.8	320	212	10.5	0.6	0.05	0.10	1.50	7
	Min	5	0.1	5	17	5.6	0.2	0.00	0.02	0.20	5
	Avg	26	1.7	80	113	7.5	0.4	0.02	0.04	0.76	6
M.2	Max	38	4.0	160	45,500	9.7	2.7	0.85	0.20	1.20	8
	Min	12	0.0	3	0	0.0	0.1	0.00	0.01	0.88	5
	Avg	28#	1.7	73	6,816+	5.5	0.5*	0.29#	0.08#	1.00#	6
M.3	Max	–	5.0	550	2,560	12.3	2.4	0.70	2.40	0.78	8
	Min	–	1.0	15	20	4.2	0.3	0.00	0.25	0.78	5
	Avg	–	1.6	110	685	7.3	0.8*	0.41#	1.33#	0.78#	6
MY.1	Max	–	6.0	350	1,400	11.5	1.0	0.50	0.20	2.42	7
	Min	–	1.0	6	0	1.8	0.1	0.00	0.08	0.55	5
	Avg	–	2.3	140	181	6.2	0.3	0.23*	0.12*	1.46*	6
MY.2	Max	39	4.5	220	418	8.1	0.8	0.09	0.07	2.70	8
	Min	12	0.8	20	42	2.2	0.1	0.00	0.01	0.78	6
	Avg	22	1.9	133	152	4.9	0.3	0.02	0.05	1.46	6
MY.3	Max	154	4.3	320	2,800	6.6	0.9	0.32	0.29	2.33	7
	Min	17	0.3	60	500	5.2	0.0	0.00	0.06	0.47	6
	Avg	58*	2.1+	154	1,600#	5.9#	0.3*	0.10	0.14	1.34	7
MY.4	Max	–	4.9	140	72,000	8.2	0.9	0.10	0.21	2.08	
										0.64	

MY.3	**Max**	**154**	4.3	320	2,800	6.6	0.9	0.32	0.29	2.33
	Min	**17**	0.3	60	500	5.2	0.0	0.00	0.06	0.47
	Avg	**58***	2.1+	154	1,600#	5.9#	0.3*	0.10	0.14	1.34
MY.4	**Max**	–	4.9	140	72,000	8.2	0.9	0.10	0.21	2.08
	Min	–	0.4	60	445	5.0	0.9	0.00	0.04	0.64
	Avg	–	2.4+	105#	22,706+	6.6	0.9#	0.06+	0.09+	1.26+
MY.5	Max	–	7.7	60	49,000	8.2	0.9	0.10	0.15	1.21
	Min	–	0.2	30	3,000	6.2	0.9	0.00	0.06	0.05
	Avg	–	2.5+	48#	39,500#	7.1+	0.9#	0.06#	0.09#	0.66+
BS.1	Max	–	7.0	120	–	14.5	1.3	0.90	–	–
	Min	–	1.0	6	–	0.0	0.1	0.00	–	–
	Avg	–	2.5	50#	–	5.3	0.6	0.45+	–	–
BS.2	Max	30	–	100	1,250	9.3	0.5	0.00	0.16	0.93
	Min	30	–	100	113	5.0	0.2	0.00	0.16	0.88
	Avg	30#	–	100#	585*	6.7*	0.3#	0.00#	0.16#	0.91#
HC.1	Max	38	2.1	320	170	9.6	0.4	0.44	0.34	2.06
	Min	18	1.3	80	60	5.2	0.3	0.00	0.00	0.53
	Avg	28#	1.8+	180+	131+	7.5+	0.3#	0.10	0.10+	1.17+
HC.2	Max	18	3.6	240	285	8.1	0.4	0.44	0.36	2.19
	Min	18	0.6	60	95	1.4	0.4	0.04	0.00	0.53
	Avg	18#	1.9#	158#	208#	5.2#	0.4#	0.12*	0.11*	1.35*
HC.3	Max	333	30.5	480	753	13.2	1.2	0.23	0.34	1.87
	Min	11	0.1	30	65	1.3	0.2	0.00	0.00	0.49
	Avg	161*	5.5	173	272	6.2	0.5*	0.10	0.13	1.03
HC.4	Max	333	30.5	200	450	10.0	0.4	0.10	0.14	2.20
	Min	190	0.1	80	110	1.3	0.4	0.03	0.00	0.64
	Avg	241*	5.3	110+	280#	5.4	0.4#	0.08+	0.05+	1.19+
S.1	Max	130	3.2	100	1,700	10.5	1.0	0.27	0.25	1.90
	Min	3	0.6	20	95	2.8	0.1	0.03	0.04	0.75
	Avg	73#	1.9#	66#	796#	6.2#	0.5#	0.11#	0.11#	1.32#
S.2	Max	95	18.0	200	970	10.9	–	0.30	0.76	3.14
	Min	22	0.6	20	167	2.6	–	0.00	0.00	0.32
	Avg	55#	3.7*	70	501	6.3	–	0.10*	0.22*	1.06*
S.3	Max	95	3.0	240	1,040	9.1	0.4	0.26	0.62	2.79
	Min	22	0.4	50	165	0.5	0.2	0.01	0.05	0.21
	Avg	56#	1.7*	107*	575	3.8	0.3#	0.11*	0.20*	1.28*
TB.1	Max	110	6.1	48	49,000	11.1	5.0	0.32	1.20	7.80
	Min	67	0.7	3	18,800	0.0	1.0	0.00	0.00	0.26
	Avg	97*	2.7	13	36,205	5.2	2.5	0.05	0.30	0.91
TB.2	Max	112	12.1	27	64,800	10.4	2.0	1.00	1.10	2.50
	Min	82	0.1	0	17,500	2.2	0.5	0.00	0.01	0.00
	Avg	99*	3.1	11	43,203	6.7	1.6	0.02	0.18	0.59
TB.3	Max	117	8.2	42	55,900	14.4	1.8	0.82	0.75	1.20
	Min	77	0.1	0	18,000	0.6	0.0	0.00	0.02	0.09
	Avg	101	1.5	6	44,053	6.7	1.0	0.02	0.16	0.51
CH.1	Max	–	2.2	200	42,000	8.6	–	0.13	0.28	2.49
	Min	–	0.5	30	3,400	0.0	–	0.00	0.00	0.00
	Avg	–	1.3*	69*	25,200*	5.3*	–	0.08+	0.05*	0.71*
CH.2	Max	–	1.7	200	24,000	8.8	–	0.16	0.14	2.68
	Min	–	1.0	30	19,000	2.6	–	0.00	0.00	0.00
	Avg	–	1.4#	93#	20,667#	6.1#	–	0.09#	0.04#	0.78#
CH.3	Max	–	2.8	120	37,000	11.1	–	0.10	0.22	1.31
	Min	–	0.8+	15	30,000	6.1	–	0.00	0.00	0.00
	Avg	–	1.5+	52+	32,200#	9.3#	–	0.06+	0.07+	0.41+

[+] Membrane filter or most probable number.

Note: To present as much information as possible from STORET data during January 1970-December 1976 and still keep the data validity in co certain qualifier signals are included along with actual data values in the "average" column:

Absence of qualifier signal	The average presented is of at least 10 observations spanning a period of at least 3 years during January 1970-December 1976.
*	Average of at least 10 observations not spanning a period of 3 years for each station within the segment.
+	Average of less than 10 observations spanning a 3-year period.
#	Average of less than 10 observations spanning a period of less than 3 years.
–	No data available.

0.32	0.29	2.33	7.8	–	–	30.5	1.8	33.0	–	5,100
0.00	0.06	0.47	6.6	–	–	12.5	1.8	13.0	–	600
0.10	0.14	1.34	7.2#	–	–	24.6	1.8#	21.5*	–	2,533#
0.10	0.21	2.08	8.7	–	–	30.0	4.0	–	–	2,400
0.00	0.04	0.64	7.0	–	–	16.0	1.0	–	–	50
0.06+	0.09+	1.26+	7.7+	–	–	24.0	2.6#	–	–	637+
0.10	0.15	1.21	8.0	–	–	30.0	3.0	–	–	128
0.00	0.06	0.05	7.9	–	–	21.0	1.0	–	–	2
0.06#	0.09#	0.66+	8.0#	–	–	25.1+	2.0#	–	–	44#
0.90	–	–	9.0	–	–	32.0	13.4	–	506	–
0.00	–	–	6.5	–	–	13.0	1.1	–	4	–
0.45+	–	–	7.1	–	–	22.9	4.2	–	189	–
0.00	0.16	0.93	7.6	–	0.94	32.0	70.0	–	49	–
0.00	0.16	0.88	7.6	–	0.00	15.5	3.0	–	49	–
0.00#	0.16#	0.91#	7.6#	–	0.22#	25.7*	25.5*	–	49#	–
0.44	0.34	2.06	8.6	–	1.35	28.0	8.0	–	–	–
0.00	0.00	0.53	6.4+	–	0.21	19.5	1.0	–	–	–
0.10	0.10+	1.17+	7.4+	–	0.81#	24.8+	2.7+	–	–	–
0.44	0.36	2.19	7.5	–	0.36	32.0	8.0	–	–	270
0.04	0.00	0.53	5.7	–	0.36	19.5	1.5	–	–	170
0.12*	0.11*	1.35*	6.5#	–	0.36#	24.8*	2.4#	–	–	220#
0.23	0.34	1.87	8.5	–	0.79	32.0	3.0	29.0	27	680
0.00	0.00	0.49	5.9	–	0.31	15.0	1.0	4.0	0	10
0.10	0.13	1.03	7.2*	–	0.49*	24.2	1.6	16.3*	14#	194*
0.10	0.14	2.20	8.4	–	0.48	28.0	3.0	–	–	160
0.03	0.00	0.64	6.6	–	0.48	15.0	1.0	–	–	160
0.08+	0.05+	1.19+	7.5	–	0.48#	23.1	1.3+	–	–	160#
0.27	0.25	1.90	8.3	–	–	31.0	3.0	–	339	144
0.03	0.04	0.75	6.1	–	–	16.0	1.0	–	15	144
0.11#	0.11#	1.32#	7.6*	–	–	25.5*	1.8#	–	73#	144#
0.30	0.76	3.14	8.5	–	0.44	31.0	7.5	16.0	114	32
0.00	0.00	[illegible]	6.4	–	0.00	11.5	1.0	16.0	75	32
0.10*	0.22*	1.06*	7.9*	–	0.09	24.8	2.5	16.0#	89#	32#
0.26	0.62	2.79	7.6	–	0.51	32.0	8.0	28.0	72	220
0.01	0.05	0.21	6.2	–	0.00	14.0	1.0	3.0	72	56
0.11*	0.20*	1.28*	7.0*	–	0.17*	23.9	2.8*	17.2#	72#	141#
0.32	1.20	7.80	8.7	3.70	3.80	33.2	27.0	17.0	31,000	122,000
0.00	0.00	0.26	6.5	1.00	0.74	15.5	0.0	1.0	3,440	100
0.05	0.30	0.91	8.0	1.88	1.95	25.4	5.9	7.1	7,963#	5,431*
1.00	1.10	2.50	8.6	1.50	1.40	33.0	24.0	26.0	4,200	6,400
0.00	0.01	0.00	7.1	0.87*	0.02	15.0	0.7	0.0	1,400	100
0.02	0.18	0.59	8.2	1.08*	0.64	24.6	4.6	6.2	3,475#	551*
0.82	0.75	1.20	8.6	5.70	2.60	32.2	32.0	14.0	5,968	1,900
0.00	0.02	0.09	6.8	0.30	0.25	12.0	0.0	0.0	4,400	2
0.02	0.16	0.51	8.2	1.53	1.00	24.3	3.9	4.4	5,046*	140*
0.13	0.28	2.49	8.5	–	0.59	31.0	15.0	17.0	–	600
0.00	0.00	0.00	7.2	–	0.08	20.0	1.0	7.4	–	2
0.08+	0.05*	0.71*	7.7*	–	0.30*	24.1*	4.5*	11.9#	–	130#
0.16	0.14	2.68	8.5	–	0.62	30.6	20.0	–	–	2
0.00	0.00	0.00	7.3	–	0.12	25.0	2.0	–	–	2
0.09#	0.04#	0.78#	7.9#	–	0.34#	28.3#	8.3#	–	–	2#
0.10	0.22	1.31	8.6	–	0.45	34.3	20.0	–	–	2
0.00	0.00	0.00	7.4	–	0.04	19.7	2.0	–	–	2
0.06+	0.07+	0.41+	8.0+	–	0.19+	26.5*	5.5+	–	–	2#

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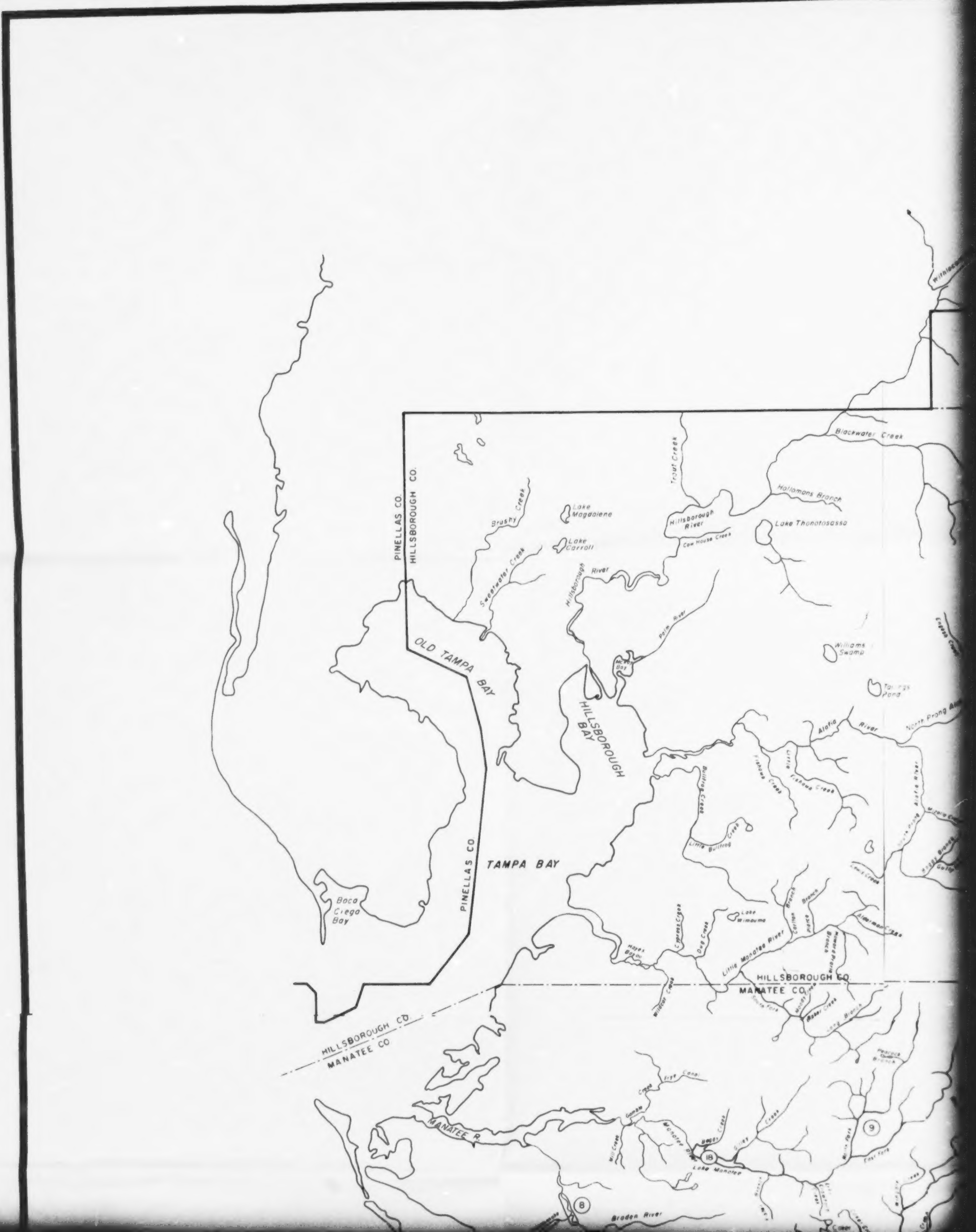
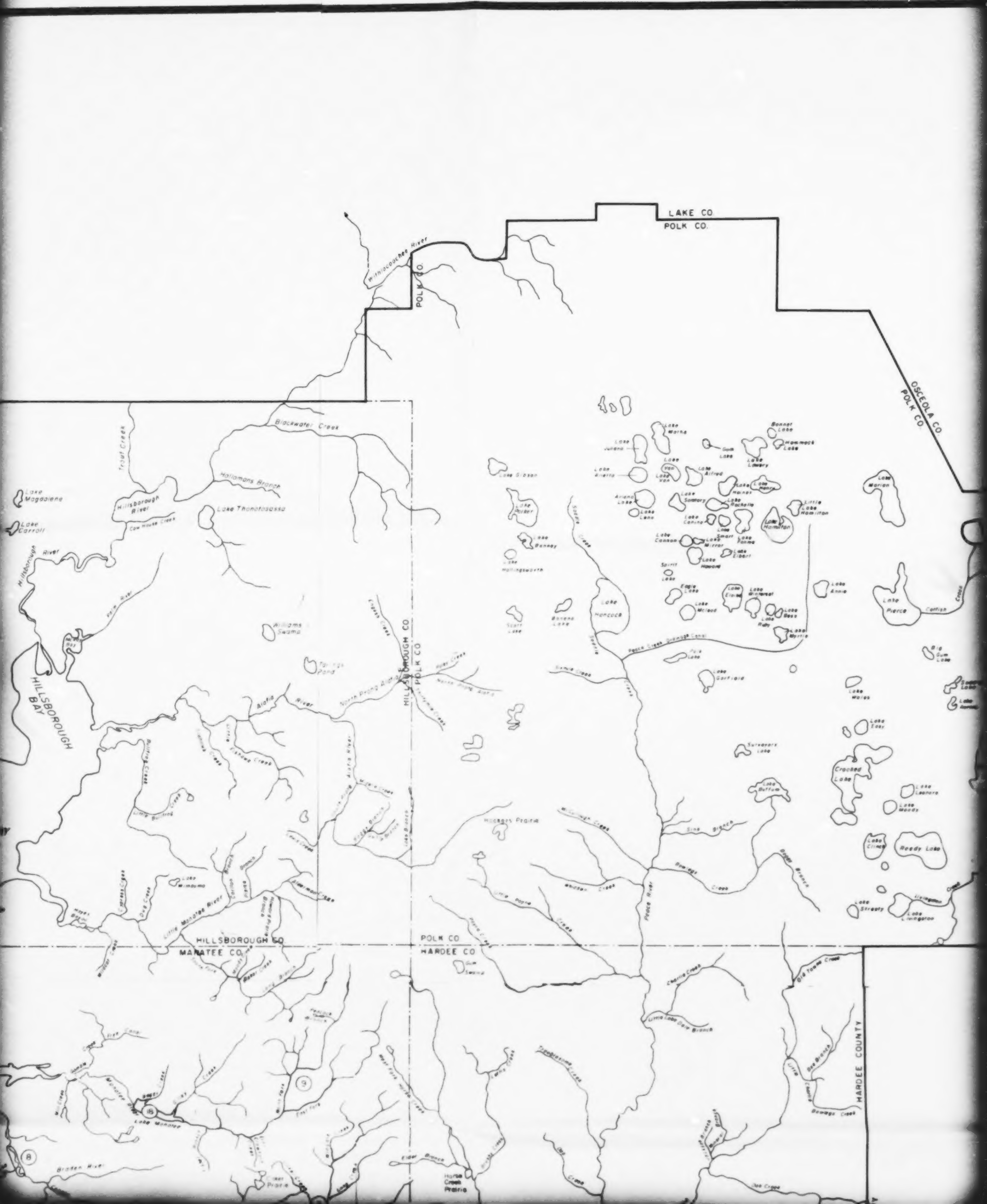
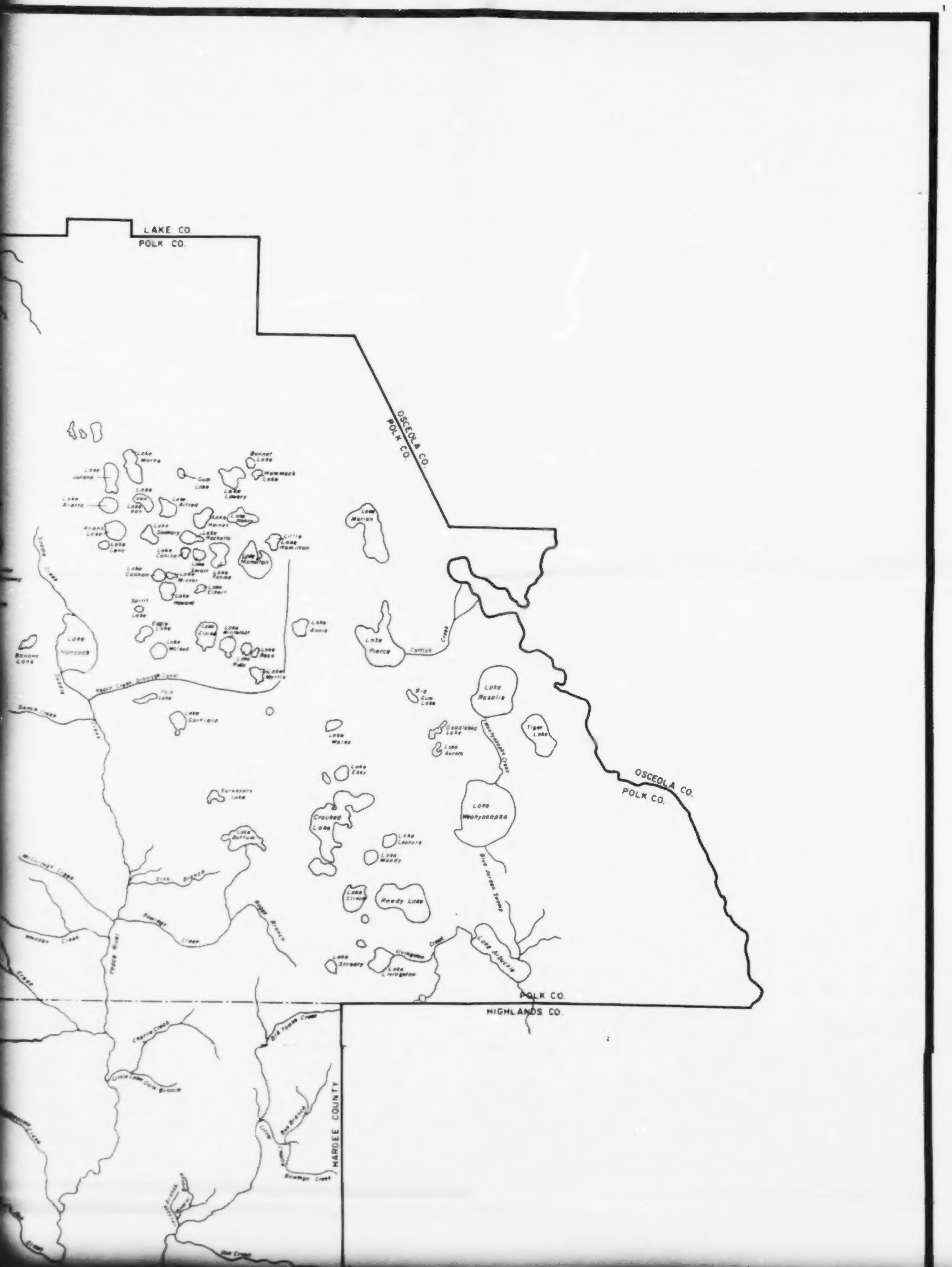
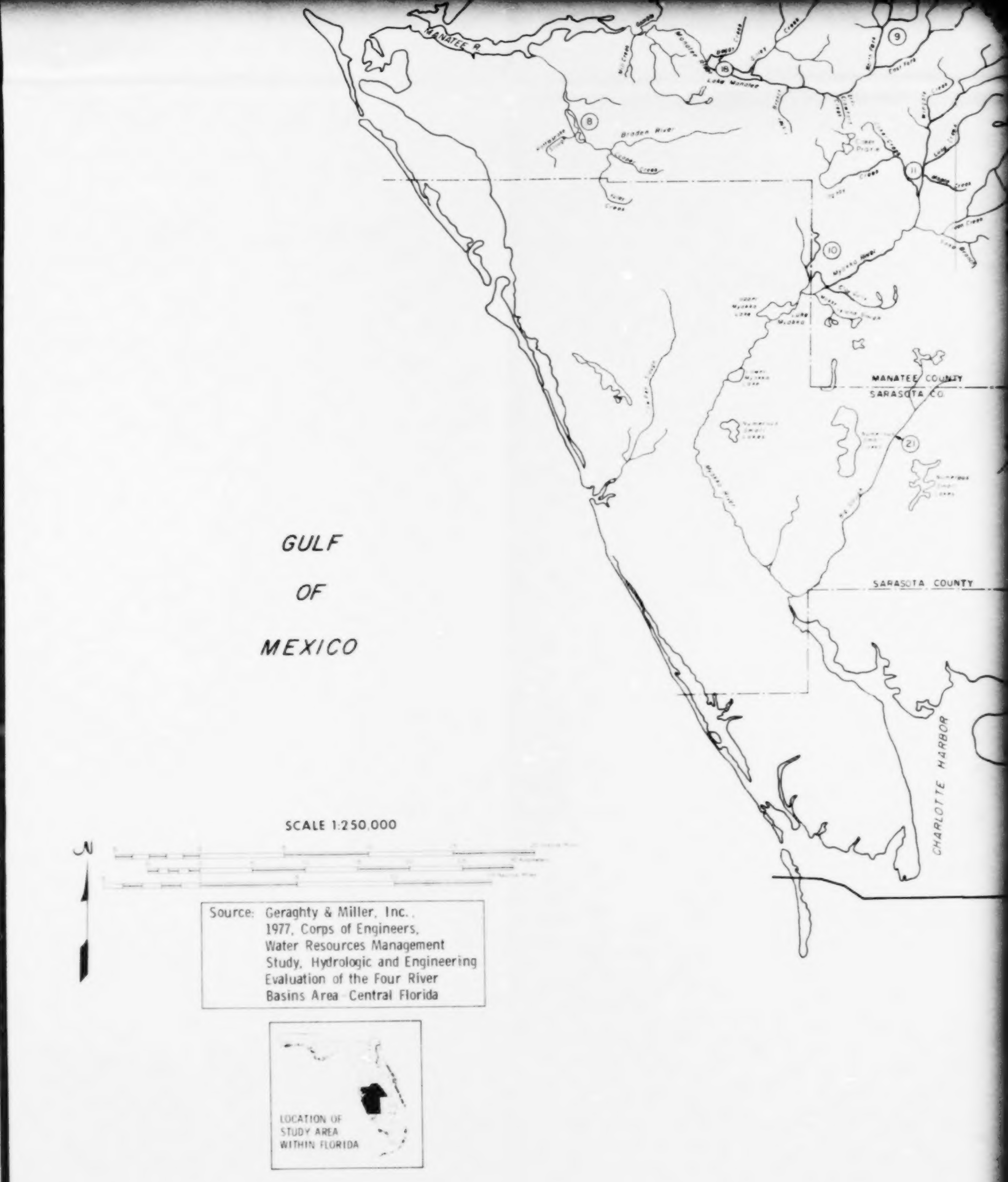
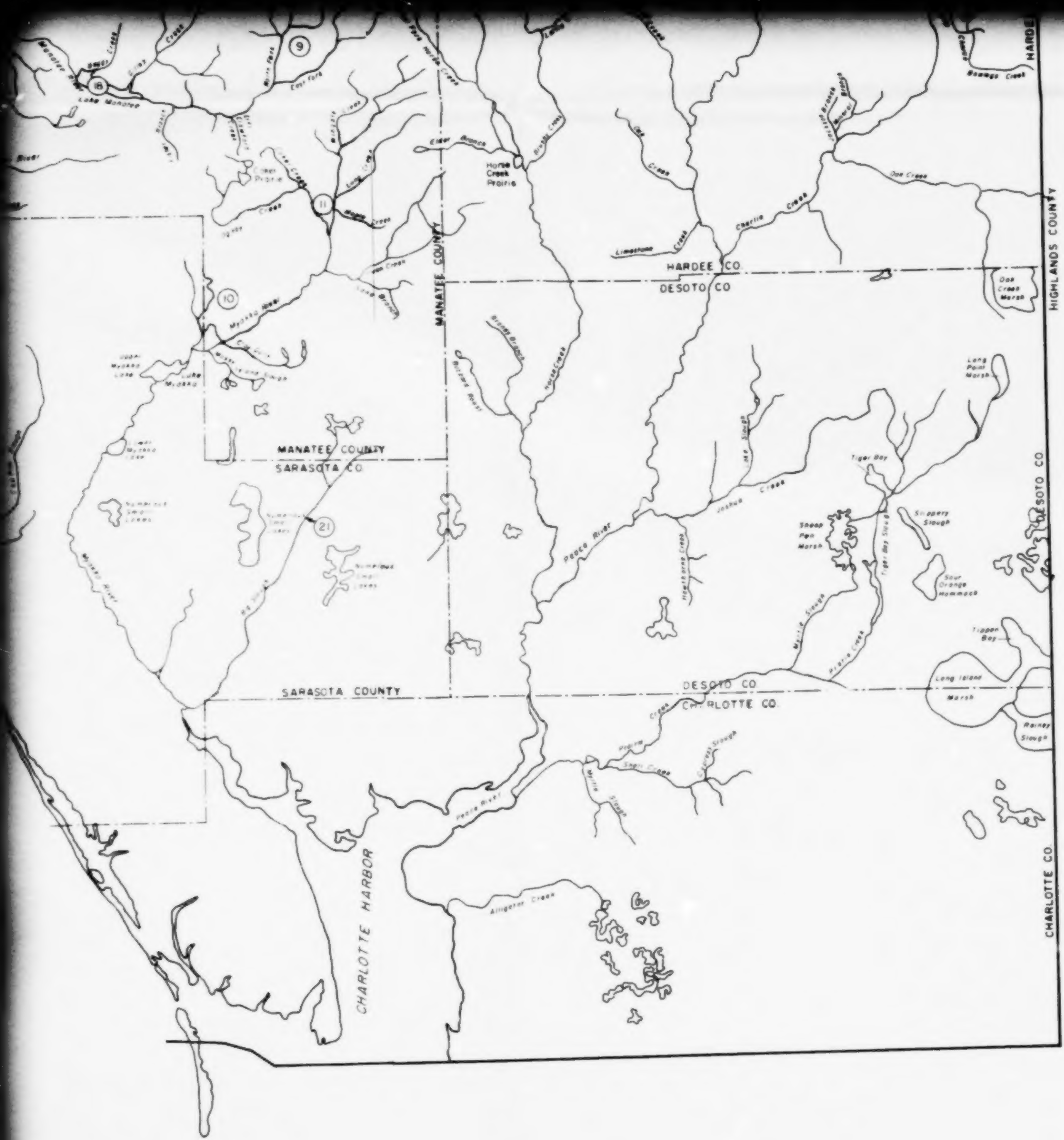

PINELLAS CO.
HILLSBOROUGH CO.
Brushy Creek
Lake Magdalene
Lake Carroll
Sweetwater Creek
Trout Creek
Hillsborough River
Cow House Creek
Blackwater Creek
Hallomans Branch
Lake Thonotosassa
Hillsborough River
Palm River
McKay Bay
Williams Swamp
Pond
OLD TAMPA BAY
HILLSBOROUGH BAY
Alafia River
North Prong
Fishhawk Creek
Little Fishhawk Creek
Bullfrog Creek
Little Bullfrog Creek
Alafia River
TAMPA BAY
PINELLAS CO.
Boca Ciega Bay
Lake Wimauma
Cypress Creek
Dug Creek
Hayes Bayou
Carlton Branch
Pierce Branch
Alderman Creek
Little Manatee River
HILLSBOROUGH CO.
MANATEE CO.
Wildcat Creek
South Fork
Baker Creek
Long Branch
Peacock Branch
HILLSBOROUGH CO.
MANATEE CO.
Frye Canal
Gamble Creek
MANATEE R.
Mill Creek
Manatee River
Boggy Creek
Gilley Creek
Lake Manatee
North Fork
East Fork
9
18
8
Braden River


LAKE CO.
POLK CO.
Withlacoochee River
POLK CO.
OSCEOLA CO.
POLK CO.
Blackwater Creek
Trout Creek
Hallomans Branch
Lake Magdalene
Hillsborough River
Lake Thonotosassa
Lake Carroll
Cow House Creek
Hillsborough River
River
Palm River
McKay Bay
HILLSBOROUGH BAY
Williams Swamp
Tarpon Pond
English Creek
HILLSBOROUGH CO
POLK CO
North Prong Alafia
Alafia River
Poley Creek
North Prong Alafia
Lake Gibson
Lake Parker
Lake Bonney
Lake Hollingsworth
Scott Lake
Banana Lake
Saddle Creek
Lake Hancock
Lake Juliana
Lake Martha
Lake Ariana
Lake Van
Lake Van
Ariana Lake
Lake Lena
Lake Sanitary
Lake Alfred
Gum Lake
Bonnet Lake
Hammock Lake
Lake Lowery
Lake Haines
Lake Henry
Lake Rochelle
Lake Conine
Lake Smart
Lake Fannie
Lake Hamilton
Little Lake Hamilton
Lake Cannon
Lake Mirror
Lake Elbert
Lake Howard
Spirit Lake
Eagle Lake
Lake Mcleod
Lake Eloise
Lake Winterset
Lake Ruby
Lake Bess
Lake Mattie
Lake Annie
Lake Marion
Lake Pierce
Catfish Creek
Peace Creek Drainage Canal
Polk Lake
Lake Garfield
Big Gum Lake
Lake Wales
Lake Easy
Surveyors Lake
Crooked Lake
Lake Buffum
Lake Leonore
Lake Woods
Lake Clinch
Reedy Lake
Lake Streety
Lake Livingston
Peace Creek
Bullfrog Creek
Little Bullfrog Creek
Fishhawk Creek
Alafia River
South Prong Alafia
Mizelle Creek
Hurrah Branch
Lake Branch
Lake Wimauma
Cypress Creek
Dug Creek
Little Manatee River
Carlton Branch
Alderman Creek
Hayes Bayou
Wildcat Creek
Hodges Prairie
McCullough Creek
Sink Branch
Bowlegs Creek
Whidden Creek
Little Payne Creek
Peace River
HILLSBOROUGH CO
MANATEE CO
POLK CO
HARDEE CO
Baker Creek
Long Branch
Gum Swamp
Charlie Creek
Old Town Creek
Little Lake Dale Branch
HARDEE COUNTY
Little Charlie Creek
Bee Branch
Bowlegs Creek
Gamble Creek
Manatee River
Lake Manatee
East Fork
9
18
8
Braden River
Myakka River
Clear Prairie
Elder Branch
West Fork Horse Creek
Horse Creek Prairie
Troublesome Creek
Oak Creek
Joe Creek

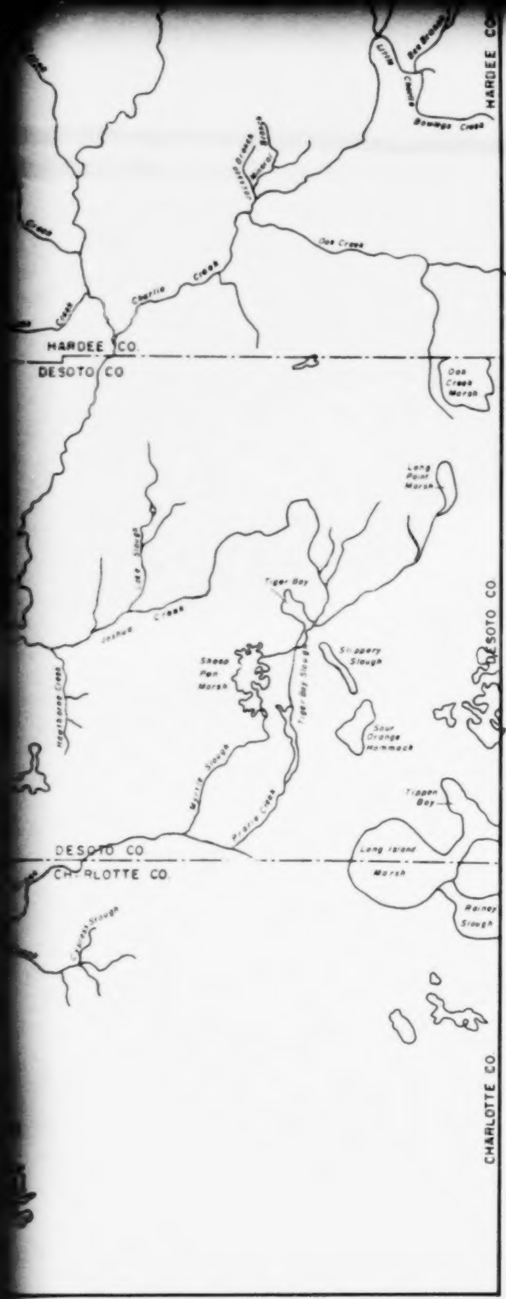

LAKE CO.
POLK CO.
OSCEOLA CO.
POLK CO.
Lake Juliana
Lake Marie
Gum Lake
Bonnet Lake
Hammock Lake
Lake Lowery
Lake Alfred
Lake Van
Lake Van
Lake Alfred
Lake Haines
Lake Henry
Ariana Lake
Lake Lena
Lake Sawmory
Lake Rochelle
Little Lake Hamilton
Lake Hamilton
Lake Conine
Lake Smart
Lake Fannie
Lake Cannon
Lake Mirror
Lake Elbert
Lake Howard
Spirit Lake
Eagle Lake
Lake Eloise
Lake Winterset
Lake McLeod
Lake Roy
Lake Rosa
Lake Myrtle
Lake Annie
Lake Hancock
Banana Lake
Saddle Creek
Saddle Creek
Peace Creek Drainage Canal
Polk Lake
Lake Garfield
Sixmile Creek
Creek
Lake Marion
Lake Pierce
Catfish Creek
Big Gum Lake
Lake Rosalie
Tiger Lake
Saddlebag Lake
Lake Aurora
Weohyakapka Creek
Lake Wales
Lake Easy
Surveyors Lake
Crooked Lake
Lake Buffum
Lake Leonore
Lake Moody
Lake Weohyakapka
Blue Jordan Swamp
Lake Clinch
Reedy Lake
McCullough Creek
Sink Branch
Bowlegs Creek
Whidden Creek
Peace River
Bear Branch
Creek
Lake Streety
Livingston Creek
Lake Livingston
Lake Arbuckle
POLK CO.
HIGHLANDS CO.
Big Tooney Creek
Charlie Creek
Little Lake Dale Branch
HARDEE COUNTY
Little Charlie Creek
Bee Branch
Bowlegs Creek
Creek


MANATEE R.
Gamble
Mill Creek
Manatee
Boggy Creek
Gilley
Creek
North Fork
East Fork
Lake Manatee
9
18
8
Braden River
Cooper Creek
Creek
Clear Prairie
Long Creek
Wingate Creek
11
Owen Creek
Tatum Sawgrass
Creek
10
Myakka River
Upper Myakka Lake
Lake Myakka
Lower Myakka Lake
Numerous Small Lakes
21
Myakka River
MANATEE COUNTY
SARASOTA CO.
SARASOTA COUNTY
GULF
OF
MEXICO
CHARLOTTE HARBOR
SCALE 1:250,000
N
LOCATION OF
STUDY AREA
WITHIN FLORIDA

Source: Geraghty & Miller, Inc., 1977, Corps of Engineers, Water Resources Management Study, Hydrologic and Engineering Evaluation of the Four River Basins Area- Central Florida


Manatee River
Gilley Creek
Creek
9
18
Lake Manatee
East Fork
North Fork
Horse Creek
River
Clear Prairie
Elder Branch
Horse Creek Prairie
Brushy Creek
11
Long Creek
Wingate Creek
Creek
10
Myakka River
Owen Creek
Long Branch
Upper Myakka Lake
Lake Myakka
Lower Myakka Lake
Brandy Branch
Buzzard Roost
Horse Creek
MANATEE COUNTY
MANATEE COUNTY
SARASOTA CO
Numerous Small Lakes
Numerous Small Lakes
Numerous Small Lakes
21
Myakka River
Big Slough
SARASOTA COUNTY
Limestone Creek
Charlie Creek
Oak Creek
Oak Creek Marsh
Bowlegs Creek
Johnson Branch
Mineral Branch
HARDEE CO
DESOTO CO
HARDEE
HIGHLANDS COUNTY
Long Point Marsh
Tiger Bay
Joshua Creek
Peace River
Hawthorne Creek
Sheep Pen Marsh
Tiger Bay Slough
Slippery Slough
Sour Orange Hammock
Myrtle Slough
Prairie Creek
Tippen Bay
Long Island Marsh
DESOTO CO
DESOTO CO
CHARLOTTE CO
Rainey Slough
Prairie Creek
Shell Creek
Myrtle Slough
Peace River
Alligator Creek
CHARLOTTE HARBOR
CHARLOTTE CO

CENTRA


Little Charlie Creek
Bee Branch
Bowlegs Creek
HARDEE CO
Jackson Branch
Oak Creek
Charlie Creek
Creek
HARDEE CO.
DESOTO CO
Oak Creek Marsh
HIGHLANDS COUNTY
Long Point Marsh
Lake Slough
Joshua Creek
Tiger Bay
Sheep Pen Marsh
Tiger Bay Slough
Slippery Slough
Sour Orange Hammock
Hawthorne Creek
Myrtle Slough
Prairie Creek
Tippen Bay
DESOTO CO
DESOTO CO
CHARLOTTE CO.
Long Island Marsh
Rainey Slough
Cypress Slough
CHARLOTTE CO.

CENTRAL FLORIDA PHOSPHATE EIS

PLATE 5 - Volume V

MAJOR WATER BODIES

Prepared by

TEXAS INSTRUMENTS
INCORPORATED

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